PRACTICAL LESSONS

IN

TROPICAL AGRICULTURE

BOOK II

BY

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THE PHILIPPINE NORMAL SCHOOL

229

ILLUSTRATED

YONKERS-ON-HUDSON, NEW YORK
WORLD BOOK COMPANY
AND MANILA
1916

(See page 77.)

FIG. 1. San Miguel irrigation canal, Tarlac Province.

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ACKNOWLEDGMENTS

THE author has placed himself under obligations to so many persons for help in the way of information, while preparing this book, that individual acknowledgment in all cases is unfortunately impossible. A grateful expression of appreciation is hereby made to all the friends and well wishers without whose cordial assistance the volume would, to a great extent, have been lacking in the qualities of accuracy and thoroughness which the author hopes it now possesses.

Among those to whom special thanks in recognition of their kindly services are due are the following: Mr. Charles S. Banks, Mr. P. W. Graff, and Mr. A. S. Arguellas, of the Philippine Bureau of Science; Mr. Otis W. Barrett, Mr. P. J. Wester, Mr. M. M. Saleeby, Mr. B. E. Brewer, Mr. Jacobson, Mr. C. W. Edwards, Dr. Best, Mr. A. M. Burton, Mr. Mariano M. Cruz, and Mr. Victoriano Borja, of the Philippine Bureau of Agriculture; Mr. North H. Foreman and Mr. Alejandro Santos, of the Philippine Bureau of Education; Mr. H. B. Ross; and Professor John W. Ritchie, of the College of William and Mary.

Grateful acknowledgment should be made in particular to governmental bureaus and departments in the Philippine Islands and the United States, to business concerns, and to individuals, for invaluable help given in securing and lending for reproduction in this work illustrations as follows:

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AGRICULTURAL COLLEGE

SUGGESTIONS TO THE TEACHER

The exercises. The exercises are to demonstrate the most important principles of agriculture. They should be carried out as far as possible, for both pupils and farmers are best taught by object lessons. The pupils will understand the work better if they are allowed to participate actively in it, and accordingly the teacher should have most of the work of the exercises done by the class rather than by himself. It is not necessary for the school to own the land upon which the field exercises are tried, as farmers will often grant the use of land for the study of a crop.

Excursions. Each excursion should have a definite object in view, and an account of each excursion should be written in the notebooks. From time to time distant farms should be visited to observe how crops are planted, cultivated, and harvested. Frequent excursions should be made to near-by farms. In most matters the farmers in your neighborhood will be your best assistants in the work of practical instruction and illustration.

Literature. Secure bulletins and books from countries where the crops are intelligently grown, and study them carefully.[1] The more one reads about plants and works with them, the better judge he is of them.

Notebook. Each pupil should have a notebook to be used for agriculture only. It is convenient if these books are uniform in size. The book should contain a record of the exercises tried in the laboratory and in the field. A drawing should be made to explain each exercise. In these drawings, require the correct proportions to be kept; if one part of a plant (the root) is twice as long as another part (the stem), the drawing should show that part twice as long.

When an exercise is completed and the results are evident, the

[1] For a list of agricultural bulletins see Appendix to *Practical Lessons in Tropical Agriculture*, Book III.

members of the class should be questioned to see that they thoroughly understand its meaning. The application to successful farming should be brought out.

The pupil should first describe an exercise on a separate sheet of paper. Then after the exercise has been corrected by the teacher, it should be recorded in the notebook.

During the first two months of school the notebooks should be marked every week. These marks should be posted where all the members of the class can see them. The notebooks should be criticized before the class, the teacher explaining the good points and the defects of each book. After a few weeks the students will understand what is wanted and then every book will be better kept.

Further instructions concerning the use of the exercises and the keeping of the notebook will be found in *Practical Lessons in Tropical Agriculture*, Book I.

CHAPTER I

THE IMPORTANCE OF AGRICULTURE

FIG. 2. Agriculture is the most important of all occupations.

AGRICULTURE is the most ancient of all occupations. Long before merchants, manufacturers, lawyers, or teachers were known, men gained their living from the soil. Long before the first books were written, men tilled their fields and harvested their crops.

Agriculture is also the most important of all occupations. The earth is the Great Mother of us all, and from her bosom we must secure our food. Not only do the farmers depend on their fields for a living, but the people in the towns and cities also must be fed from these fields. Without agriculture, crowded cities with their beautiful buildings could not exist. Without the food which comes from the land, no manufac-

turing and no commerce could be carried on. The most important man in all the world is the farmer who plows the fields and gathers in the crops. He is the king among the citizens of the world. Great men have always recognized that the welfare of mankind is dependent on intelligent cultivation of the soil, and through all ages poets have sung of nature and of the fruits of the land.

The importance of Philippine agriculture. The wealth of the Philippines is in the land. We lack great deposits of coal and iron to make us a manufacturing people. We do not lie in the great world paths of commerce. But the soil is rich, the rainfall abundant, and the bright sunshine on the fields awaits only the farmer's hand to turn it into gold. It is from the soil that Filipinos must draw the wealth they need to build their roads and railroads, to provide themselves with ships, to build their factories, their cities, and their churches and schools. Only to Mother Earth can they look for the money that they must have for their education and books, their music and their art, for all those enrichments and comforts of life that civilization provides. If the Filipino people cultivate their land well, they will become rich and prosperous. If they allow the land to lie idle or if they farm it without intelligence, they must live in poverty. Nature is bountiful and she offers us great wealth, but she gives her riches only to those who seek them in the right way.

The principles of successful agriculture. The needs of plants are everywhere the same, and the principles of successful farming are the same in all lands. The following practices, therefore, must be observed by the farmer in the Philippines as well as in other countries, if he is to be successful in his work:

FIG. 3. A drainage ditch in the Federated Malay States, showing one way of controlling the amount of water in the soil.

1. The farmer must control the amount of water in the soil by drainage, by irrigation, and by the use of soil and vegetable mulches. This is necessary because all plants must have a proper supply of water for their best growth.
2. The farmer must prepare a deep and thoroughly pulverized seed bed, so that the roots of the plants can strike down deep in their search for food and water.
3. He must plant only seeds that have been carefully selected from the best varieties; for plants are like people in that some of them are better than others.
4. He must give his crops proper spacing; that is, he must give the right amount of standing room to each plant, hill, or row. This is a very important point, for if plants are too crowded they cannot thrive for lack of sunshine, and if they are placed too far apart, the use of some of the land is lost.

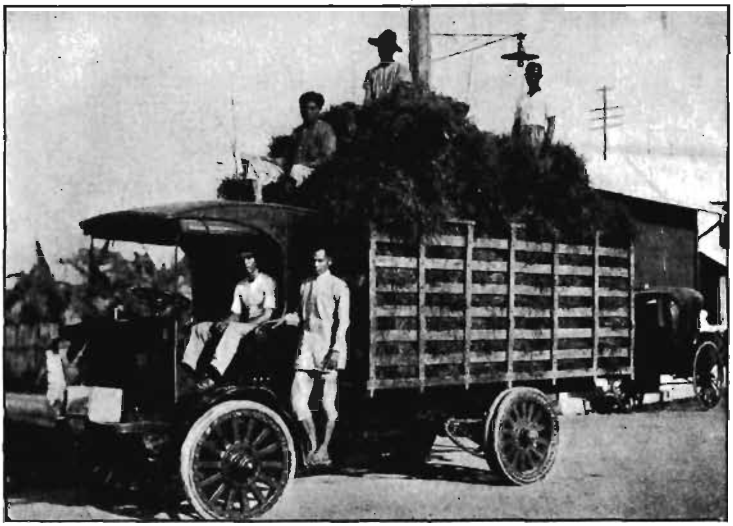


FIG. 4. Delivering barit in Manila. Modern methods of transportation are the most economical, but they demand good roads.

5. He must cultivate his crops frequently during the growing season. This is to kill the weeds and also to loosen the surface of the soil so that the water will not be lost.
6. He must add to the soil a sufficient quantity of vegetable matter.
7. He must change the crops on his fields from time to time; for a crop does not do well when it is planted repeatedly on the same land.
8. He must select crops that grow well on his land.
9. He should raise on the farm nearly all the food needed for the men and animals there. If the farmer buys this food, the men who raise it make a profit, the men who transport it make a profit, and the man who sells

it to the farmer makes a profit. Besides this cost, much valuable time will be taken in hauling it from the stores and markets. The farmer can save this time and these profits by raising the food on his own place.

10. He should keep enough farm animals to use all the waste products on the farm and to pasture on land that may be idle. Anything that goes to waste on a farm is lost, but it would become valuable if it were used to support an animal.
11. He should use strong animals and the best agricultural implements, in order that he may do more work in a day. The doing of work requires strength, and the intelligent farmer uses the great strength of animals as much as possible.
12. Finally, the farmers in a district will often find that higher prices can be obtained for their products if they will coöperate and hire an agent to sell their products for them. The coöperative society might have a storehouse at the point of shipping, or even at Manila. By thus coöperating in selling their products, the farmers in certain parts of the United States are now gaining much more than they otherwise would.

In Book I of *Practical Lessons in Tropical Agriculture* we studied a few of the needs of plants and learned how to use this knowledge in the growing of garden vegetables and fruits. In this book we shall make a further study of the principles of agriculture, and we shall consider the application of these principles in the growing of field crops.

NOTE. It is intended that this chapter be read and the general ideas in it impressed on the class, rather than that it should be carefully studied and recited on in detail.

CHAPTER II

THE FARM AS A PLACE OF BUSINESS

FIG. 5. A wagon loaded with grain, drawn by four Indian Nellore bullocks. One man is driving the four animals.

EVERY farmer should ask himself: Why do I own a farm? Why do I plow my land and cultivate my crops? Is it because I love to work? Is it because it gives me pleasure to watch my crops grow? It is pleasant indeed to work in the mellow earth and to see plants flourish under our care, but we do not follow agriculture for the love of the work.

The main purpose in farming is to get a living from the land for the farmer and his family. A poor farm poorly managed will give a poor living. A good farm well managed will give a good living. It is important for us to understand that the object of farming is to keep us in comfort and to give us money enough to buy the things that we need. The farmer who understands this will be planning constantly how he can make his farm pay him the highest possible wages for his work.

Selecting a farm. In selecting a farm, the most important point is to get soil that is fertile. The farmer's living must come out of the soil, and a rich soil makes possible a rich living. There is yet much fertile land in the Philippines that the government will give to any farmer who will live on it and use it. Any Filipino who wants a good farm may secure one.[1]

Another point that must be considered is the distance to markets and the condition of the roads that lead to these markets. It is not enough to raise crops. The farmer must also be able to sell them before he can make a profit from his land.

Still another point that the farmer must bear in mind is the question of health. The place must be healthful, for if he and his family are sick, he cannot hope to make farm life attractive or to gain the profits that he ought to have from his farm. The healthfulness both of the region and of the particular farm should be well considered, therefore, before a farm is selected as a home.

Securing a title to the land. The first thing that a farmer should do is to secure a title to his land. In the Philippines, people often settle on the land and live on it for years without any question of ownership. They build houses and fences on it, they plant the fields, they set out trees, and the farm becomes valuable. Then some one else tries to take this land, and the farmer must spend large sums of money in the courts to keep the farm for his wife and children. Sometimes he loses it entirely, and everything that he has earned by his labor goes to some one else. All this can be avoided if the

[1] Information in regard to the homestead laws of the Philippines will be found in Book III, the volume following this.

farmer will get from the government a title to his land. He can easily learn how to do this, and when it is done he is secure in his rights for all time.[1]

The farmstead.[2] The buildings needed on a farm are a house, a barn, a granary, and shelters for the chickens, hogs,

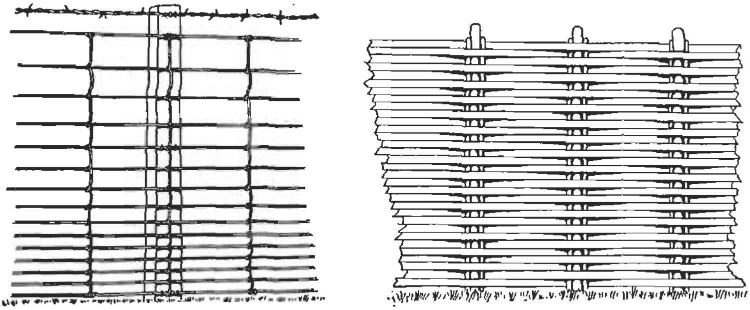


FIG. 6. The strongest and most permanent fence is made of concrete posts and woven wire, but a well-woven bamboo fence makes a good temporary substitute.

and other animals. Sometimes some of these buildings had best be combined under one roof. A high, well-drained place should be selected for the buildings, and the ground about them should be kept free from weeds. Each building should be attractive, strong, well-built, and so constructed that it will give protection from dampness and from wind. At first the farm buildings may be small, but they should be planned in such a way that they can be enlarged in later years. The different buildings should be placed at convenient distances

[1] For a discussion of land titles, see Book III.

[2] "Farmstead" means the house and other buildings belonging to the farm, with the land about them. It does not include the fields where the crops are planted.

from the house, and they should be connected with the house by walks of gravel, sand, stone, or cement.

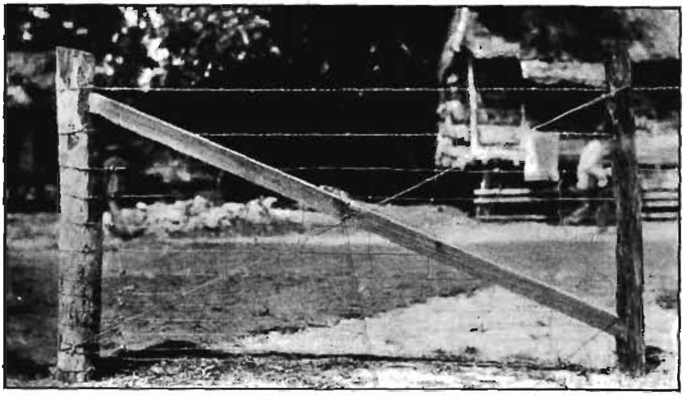


FIG. 7. A good method of bracing the end post of a wire fence.

Fences. Fences protect the farmer's crops from injury by carabaos, goats, hogs, or other animals. This is very important; for the farmer has spent his time and money in raising these crops, and if he loses them his income is gone. Another advantage in fences is that they are a great aid in controlling animal diseases. Another is that when animals are wanted for work, valuable time need not be lost in hunting them.

Wire fences last for years, and the farm should be fenced with them as soon as possible. Until a farmer can afford to put up wire fences, he must use fences of living shrubs, bamboo, or other materials. Often these fences cost the farmer nothing except his labor, but they last only a short time and the fencing problem is always on hand. As soon as possible, therefore, the farm should be permanently fenced.

Caring for the farm. The farm buildings and fences should be kept in repair. Drainage and irrigation ditches should be

FIG. 8. A flowing artesian well. Artesian water does not contain disease germs and is excellent for drinking.

kept clean. Fence rows and fields should be free from weeds and shrubs, and everything about the farm should be kept tidy and in good repair. This makes the farm attractive and also adds to the farmer's profits.

The farm water supply. A supply of pure drinking water is absolutely necessary if the farmer and his family are to enjoy health. Among the diseases that are carried by water are typhoid fever, cholera, and dysentery. No water that is used for bathing or for washing clothes should be permitted to drain into the place where drinking water is obtained.

Artesian wells. The best water for drinking purposes is usually secured from an artesian well. In many towns of the Philippines, these wells are now in use, and they have greatly

reduced the amount of sickness and the number of deaths. Artesian wells are expensive, and unless a farmer has some wealth, he will not be able to have a well of this kind on his farm. In many localities it is possible, however, for a number of farmers to coöperate and have an artesian well together.

Shallow wells. The cost of artesian wells makes it necessary for most farmers to use water from shallow wells. A well of this kind may be made safe if it is well located. It should be on high land, so that surface water will not flow into it. Manure piles or privies should not be placed near it. The well should be covered with a tight curb and the ground about it graded, so that no water will stand near it, and a pump should be placed in it.

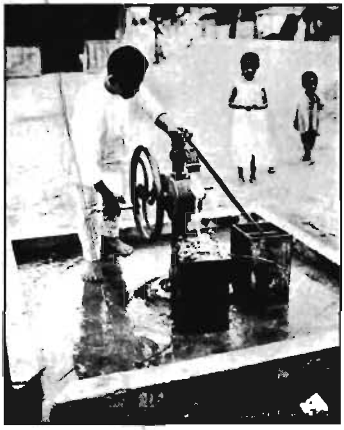


FIG. 9. A sanitary well where good drinking water is obtained. The rotary pump is recommended for all wells where the water is to be lifted not more than 9 meters. Note that surface water cannot get into this well.

Many of the wells now in use in the Philippines are open and the people dip their vessels into them. The natural result is that these waters contain microörganisms [1] that cause disease, and the people who use the water suffer from cholera, dysentery, typhoid fever, and other diseases.

[1] "Micro" means small, and an organism is anything that has life. Plants and animals that are so small that they cannot be seen without a microscope are called microörganisms. Any of these microörganisms that grow in the bodies of men or animals and cause disease are called disease germs.

Driven wells. In many districts an excellent well can be secured by driving an iron pipe into the ground till good water is reached. Special machines are made to drive the pipe into the ground. These wells are more sanitary by far than dug wells. They should be located on land higher than where a kitchen, privy, or stable is located, and the soil near the well should be graded up to prevent water from standing near. The water is drawn by a pump that is screwed on top of the pipe.

The farm garden. One of the advantages of farm life is the abundance of good, healthful food that a farmer can always have. Much of this food comes from a section of the farm which is called the *garden*. The garden should be located near the house in order that its products may be easily gathered. Any one wishing to enjoy the full comforts of a farm will provide ground for a garden with an abundance of vegetables.

Roads. Roads leading to the various fields should be laid out on the farm. Good farm roads make it possible to go from the house to the different fields without destroying crops or packing the soil of a field.

The road leading to the neighboring town which is the farmer's market for his products, is usually a public highway. The farmer has a direct interest in this road and he should see that it is well kept. If necessary he should be willing to do a certain amount of free road work. Good roads will increase the value of his farm; for his animals will be able to draw heavier loads and less time will be used in marketing his crop. They also make it more convenient for the farmer and his family to go to church, to school, to market, and to public meetings.

FIG. 10. A well-kept road with coconut trees along the side. Notice the ditch for carrying off rain water; the grass, which is kept short, prevents the soil from washing away. On a road like this, farm products can be marketed quickly and cheaply.

Field arrangements. On a good farm the fields are properly arranged. They should be so laid out that the farmer can easily get to each one from the house. If possible, they should be long and narrow, as fields of this shape are more easily tilled. As far as possible, the fields should be of the same size. Crops should be selected for each field, so that the fertility of the soil will be maintained or increased and the largest profit secured. The changing of the crops on the fields, which is so necessary in good agriculture, is possible only on farms that have a definite field plan.

General farms and one-crop farms. Some farmers divide their time among several crops. Other farmers give special attention to a single crop and are known as one-crop farmers.

Usually a farmer should grow more than one crop. First of all, he should produce those things that are needed on the farm, — food crops for the family and the farm animals. On certain farms it would be advisable to raise bamboo for buildings and fences. Then the farmer should raise a money crop, — like tobacco, copra, or abacá, — to bring in a certain amount of money each year. When a farm is planted to a single money crop, a portion of the land should be left for the cultivation of food plants; for experience shows that a farmer is more prosperous when he is not compelled to spend for food the money that he gets for his money crop.

No matter what cropping plan is decided on, the crops that are best suited to the soil and climate and that are the most profitable should be grown in large quantities. In one community it may be best to make the main crops rice, cowpeas, and corn. In another community tobacco, cowpeas, and corn should be the main crops. In still other regions, coconuts or abacá may be the leading crop, or cattle raising may be most profitable.

Domestic animals on the farm. A successful farm must be equipped with animals. These will consist of animals for working purposes and animals raised for food. The farm should have sufficient work animals to keep the land under proper cultivation. Hogs, goats, and chickens, ducks, and other poultry also add greatly to the profits of a farm. A farmer should keep breeding animals and raise his work animals instead of buying them. The sale of eggs and chickens or ducks, now and then, should bring in a large part of the money needed to buy such food products as are not produced on the farm.

Farm tools and implements. The buildings, fences, animals, tools, with everything else that the farmer needs in living and in carrying on his work, are called the *equipment* of the farm. In this chapter we have considered a part of this equipment. The remainder we shall discuss in a later chapter (page 27).

EXERCISES

Exercise 1. To draw a plan for a farm. Have each pupil examine closely a farm in the locality, using his own home farm, if possible, for this work. Make a map of the farm, showing the arrangement of the fields and the location of the buildings and garden. Relative proportions showing exact distances should be used in making the map. Then make another map showing, if possible, a better arrangement of fields, buildings, and drainage ditches for that particular farm. A farmer will often find it to *his advantage to change the plan of his farm.*

Exercise 2. To plan a farmstead. Have each pupil draw a plan of a farmstead, using his own home as a basis for the plan. The location of the house, barn, privy, well, hog yard, garden, fences, and walks should be shown, with the distances between the buildings.

NOTE. The teacher should discuss these plans with the class and should at once rule out everything that is not practicable in the conditions under which the pupils live. On old established farms the plans cannot be changed at once, but the possibility should be pointed out of making a better plan and of gradually changing to it as new buildings are put up and crops are rotated. On some farms the present plan may be entirely satisfactory.

CHAPTER III

THE FARM AS A HOME

FIG. 11. A good farmhouse. This house has a porch on two sides. It has a sitting-room, a dining-room, and two bedrooms. The kitchen and the bathroom are in a separate building at the rear.

IN the first chapter we learned that the main purpose in farming is to gain a living. We must not forget, however, that agriculture is a life as well as an occupation; that both the farmer's work and his life are at home; and that one of the great advantages of agriculture as an occupation is that the farmer and his family are furnished with a home.

In considering the farm as a home, the convenience, the comfort, and the health of the farmer and his family must be kept in mind. We must also understand that money spent to make the home beautiful is not lost; for beauty and pleasure should be a part of every life, and the beauty which we most

FIG. 12. A Filipino farmer's home, with only one room, other than the shed. Each house should have two or three separate rooms.

enjoy is that which is in our homes. Anything that makes the home pleasanter makes it easier to keep the boys and girls on the farm and gives them a greater interest in their work. The farmer cultivates his land in order that he may have enough wealth to allow him to enjoy the comforts and pleasures of life. One of the first uses he should make of his money is to provide for himself and his family a comfortable and attractive home.

The farmhouse. The farmhouse is the center of the farm home. It should be attractive, comfortable, and well-constructed, and it should be kept clean and tidy. It should be located on high, well-drained land, where there will be a good playground for the children and dry soil for the raising of poultry and other domestic animals. It should not be built near the breeding places of mosquitoes; for these pests not only cause great annoyance, but also carry microörganisms that cause disease.[1]

[1] Mosquitoes carry the germs of malaria, and dengue fever also is contracted from the bite of the mosquito.

The house should be provided with eave troughs so that the water which falls on the roof during storms may be easily drained away. Make the ground near the house level or gently sloping, and dig ditches to drain the surface water away. Surface water should not be allowed to run toward the house or into the well from which drinking water is taken. Neither stagnant water nor bowls or jars of water that will allow mosquitoes to breed should be left about the house.

Sanitary toilet arrangements. The health of the farmer and his family is all-important, and wherever human wastes are not carefully disposed of health is lost and disease abounds. Sanitary toilet arrangements should, therefore, be a part of every country home. Where it is possible to pipe water into the house, this should be done. In this way water will be furnished for household use, and a modern water-closet may be installed. If a water-closet is not possible, a sanitary privy should be provided.[1]

The yard. A great painter sometimes uses all his art to picture a beautiful farmhouse. Such a picture does not show a bare house, but a house sheltered among shrubs and trees, with flowers and fresh green grass about it. City dwellers often hang pictures of such scenes on their walls, but the farmer may own the scene itself if he will but give attention to his yard. What to do to improve the appearance of the yard depends on its size, the nature of the soil, whether there are trees, and many other circumstances; but some general suggestions may be made that will be helpful in beautifying any yard.

[1] For information on this subject send for Bulletin No. 10 of the Philippine Bureau of Health and for Farmers' Bulletin No. 463, United States Department of Agriculture, Washington, D.C. No charge is made for these bulletins.

FIG. 13. A well-kept yard. A violeta hedge must be trimmed with shears. To keep a lawn in good condition, the grass is cut with a lawn mower.

Making a lawn. Soil covered with grass which is kept short by frequent cutting is called a *lawn*. There is nothing prettier than a well-kept lawn, and every house should have a few square meters of green grass. In preparing a yard for a lawn, it is necessary to fill all low places with soil. In order that rain water may run off quickly, the ground should have a gentle slope (3 centimeters in a distance of 10 meters) away from the house. After a low place has been filled, cover it over with topsoil, as grass will not grow well in subsoil that has recently been brought to the surface. After the soil has been leveled, till it deeply, make it soft and fine, and work into it compost (page 62) or other decaying vegetable matter. When leveling soil, drive into it four stakes, 8 to 10 meters apart, in the form of a square and stretch a long string between the stakes, close to the ground. The slight elevations and depressions can thus be easily determined and the soil made

level or of an even slope. Bermuda grass (Fig. 14) is the best grass for a lawn and can be found in every part of the Philippines. Gather the creeping stems and plant them thickly in rows 20 centimeters apart, leaving about a third of the stem above the soil. Roots will grow from the nodes, and in a short time, if the soil is properly watered, the grass will start to grow.

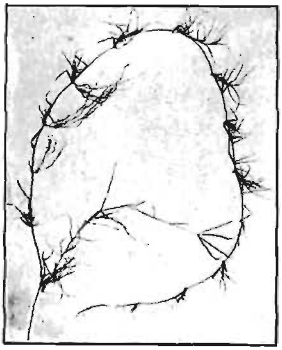


FIG. 14. Bermuda grass (*Cynodon dactylon*), known also as grama, galot-galot, kawad-kawaran, malit.

Usually many rank-growing grasses make their appearance in a new lawn, but these should be dug out with a knife and only Bermuda grass left in the lawn. About three weeks after the grass has been planted, or after it has a good start, tamp the soil with a block to level ridges that were made when the grass was planted. Water the lawn during the dry season and scatter compost over it once or twice a year. Mow the grass about every ten days. This may be done with a sickle or with a lawn mower. Sweep up the cut grass and dump it into the compost pit.

Making paths. Paths may be made either straight or curved, and should be 1 meter or more in width. Paths in a small yard should as a rule be straight. A path leading from a schoolhouse or other public building, over which many people are to pass in a short time, should be 3 meters or more in width.

When making a path, stretch a string along each side, and remove the soil from the path to the depth of 15 centimeters.

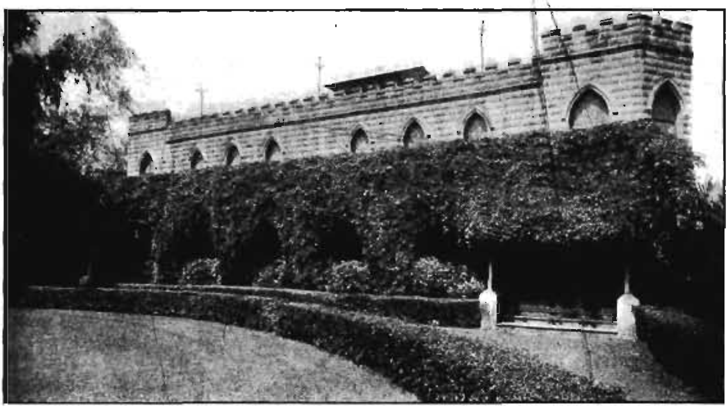


FIG. 15. The ayo vine makes an excellent shade for a porch.

This soil may be used to fill in low places. Cover the bed of the path with rocks the size of your fist and tamp them down with a block of wood; add smaller rock or gravel, and tamp again; then cover the surface with gravel or with small shells from the beach. The middle of the path should be somewhat higher than the edges.

Placing of trees, shrubs, and herbs. Sunshine and air are great health givers and should not be kept out of the house. As a rule, shade trees should be 6 meters or more from a house. If too near, they tend to keep the place damp and make it attractive to mosquitoes; if they are too close together, the grass below does not grow well. Ferns grow well in shady places. Plant decorative herbs, shrubs, and shade trees where they will not interfere with the garden. These plants should not be scattered here and there over the lawn, but should be placed in corners and at other places out of the way. It is not desirable to use bottles, bricks, tiles, stones, or eggshells to decorate yards.

There are in these Islands five hundred or more plants suitable for yard, street, and park decoration, and many of them are growing in each municipality.[1]

Growing trees. Where trees are wanted for decorative and shade purposes, care must be taken in growing the young trees and in transplanting them. The following directions for transplanting an acacia will be found to apply in most respects to other kinds of trees as well.

Gather seeds from a large acacia tree and plant them 3 centimeters deep in rows 6 centimeters apart in a garden plot. Keep the soil moist. When the plants are 30 centimeters high, transplant them, setting them carefully 1 meter apart in a well-tilled plot. All the plants with crooked stems should be thrown away. When the stems are about a meter long, they need a support, or frame, to keep them straight and to keep them from being swayed by the wind. To support them, drive one or two stakes near each tree; then take a strip of cloth 10 centimeters wide from an old rice sack, and wind it loosely around the stem. Place pieces of bamboo over the cloth, and with strong string tie the tree to the stakes. The bamboo and the cloth prevent the string from cutting into the bark of the stem.

When the stem is about 150 centimeters high, pinch off the top bud. This will start the side branches. The lower branches should be removed with a sharp knife and the upper ones pruned back to make the tree form a close head. When the stem is about one year old and the trunk has a diameter of about five centimeters, the tree is ready to be transplanted to its permanent place.

[1] In the appendix of Book III a list of some of the plants that may be used for shade and decorative purposes is given.

Transplanting a tree. To lift the tree from the soil, dig a narrow circular trench around the tree about 30 centimeters from its base. The tree should be taken up with a ball of earth attached to its roots. Before this ball of earth is lifted, slip under it a rice sack that has been cut open, and tie or sew the sack at the top. This prevents the soil from falling away from the roots. The tree is now ready to be moved. The best time to transplant a tree is on a rainy day during the rainy season.

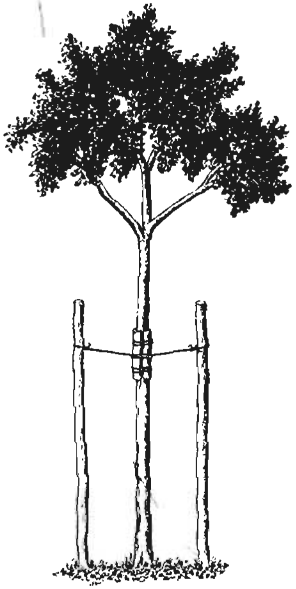


FIG. 16. An acacia tree one year old, just transplanted to its permanent place.

At the place where the tree is to be planted, dig a hole about 60 centimeters square and 60 centimeters deep. The harder the digging, the larger and deeper the hole should be. Then partially refill the hole with rich topsoil. Place the tree in the hole, setting it as deep as it stood in the nursery. The sack may be left in the soil or it may be removed. Fill the unoccupied space with rich topsoil, packed down with a stick or with the foot. Add several kerosene cans of water to settle the loose earth. Thirty centimeters from the tree drive two stakes into the soil, one on each side of the tree, and tie the tree to the stakes, as explained above. The tree will thus be kept erect. After the tree has been transplanted it should resemble the tree in Figure 16. Water the

tree during the dry season and prune it once a year, at the beginning of the rainy season. The top should be kept well balanced, like an umbrella. The soil within one meter from the base of the tree should be thoroughly tilled for two or three years. A kerosene can of compost or other manure worked into the loose soil will furnish the tree with additional material for food. Cover the soil with a vegetable mulch during the dry season.

The plaza. Every town or barrio needs a plaza, in as central a location as possible. This is needed not alone for the purpose of beauty, but to serve as a place of recreation as well. The plaza is to the whole town or barrio what the yard is to the house or the school. It should be kept a model of neatness, but there should be no restrictions that will prevent its being used for the common benefit and pleasure of the people. Its condition, together with that of school yards, streets, and markets, shows how much pride the people have in their town.

The care of the plaza. The soil of the plaza should be leveled off as for a yard and planted to a lawn, with a row of shade trees around it next the street. Drainage should be carefully looked after. If the plaza is large and no other suitable grounds are near, a certain portion of it may be given over to such games as base ball, basket ball, and tennis. Paths of a suitable width should be constructed across the plaza where people are most accustomed to pass. Along the edges of the paths there should be nothing to trip children at play. A hedge is sometimes made to border paths across a plaza, but this spoils the plaza as a playground.

Selecting trees for street planting. In selecting trees for street planting, it is better to plant only one variety to a

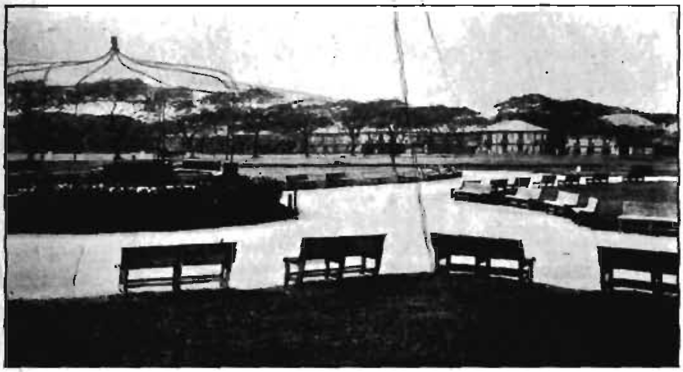


FIG. 17. A good plaza.

street. A public road lined on both sides with large trees of the same kind is beautiful and harmonious, while one planted to mixed varieties is irregular and not nearly so attractive. Each village or barrio should have one street with mangoes along each side; other streets might be bordered with acacias, royal palms, coconuts, mabolos, santols, or bamboo. Along a roadside, trees like the acacias should be planted 30 meters apart.

EXERCISES

Exercise 3. To recognize the common decorative plants. Have the class make a list of five flowering herbs, five shrubs, five vines, and five trees, all grown in the locality, that are most suitable for yard improvements. If possible, have leaves and flowers of each of these brought to the school in order that the pupils may become familiar with the plants. Both the local names of the plants and the English names, when these can be found out, should be learned.

Exercise 4. To gather ideas in regard to beautifying yards. Have the class visit several of the houses in the neighborhood which have the best yards. Let them sketch in their notebooks the plan of each yard and discuss these plans in writing.

Exercise 5. To plan a yard. Have each pupil make a plan for the improvement of the yard at his home. The plan should be practical, involving no greater outlay of labor and money than is necessary, and any plants called for by the plan should be of a kind that can be easily secured.

Exercise 6. To plan improvements for the school yard. Have the pupils make a study of the school yard. Discuss improvements that may be made in it by the planting of flowers, shrubs, and trees and by the laying out of walks. Discuss only plans and suggestions that are definite as to the kinds of plants to be used and the places where they should be planted. Follow up these plans by making the plantings decided on.

Exercise 7. To demonstrate the proper method of transplanting a tree. Transplant one or more trees to some desirable place, following the directions given on page 23. Be sure that the work is done properly. *Do not demonstrate wrong methods to the class.*

CHAPTER IV

FARM IMPLEMENTS AND THEIR USE

Fig. 18. Deering peg tooth harrow with riding attachment.

Every farmer must use implements in his work, and every farmer must decide for himself which ones he will buy; for the number of implements and the kinds of implements that he needs depend on the crops that he raises and on the size of his farm. The implements that are needed on an abacá farm are different from those needed on a grain farm, and to farm a few hektars, fewer implements are needed than are necessary for a large plantation.

Tools, implements, machines, and vehicles. A *tool* is a small implement that may be used either in the field or in

the shop. The hammer, hoe, bolo, sickle, file, and spade are tools.

An *implement* is larger than a tool and is commonly used in the field. The plow, harrow, and cultivator are implements.

A *machine* is usually more complicated than an implement. We have machines for lifting water, for cleaning abacá, and for threshing rice. There is, however, no clear line of distinction between a tool and an implement, or between an implement and a machine.

The sled, cart, wagon, car, bicycle, and automobile are *vehicles*. They are used for transporting persons or things.

In the first paragraph of this chapter we have used the word "implement" to mean everything that the farmer uses in his work, but it is well to understand the meanings of the words given above.

Tools. The tools for field work on a farm are about the same as the tools necessary for a garden. The spade, spading-fork, Chinese spade, rake, goose-neck hoe, strong hoe, mattock, bolo, and sickle, with possibly certain tools for working in wood and iron, will usually be needed. As a rule, tools are carefully made and, if rightly used, will last for a long time. The goose-neck hoe is especially likely to be broken, but if kept sharp and used only in well-tilled soil it will last for years. It has the advantage over the strong hoe of being light and of being easy to keep sharp with a file.

There are many small hand-tools now used in harvesting Philippine crops. A small hand-knife is used to cut the heads of rice; oddly constructed sickles are used in harvesting rice; a chisel-like knife is used to remove the partly dried meat from coconut shells; and a small, thimble-like knife is used to cut the stems of betel leaves. These simple

FIG. 19. Plowing with a disk plow.

tools are serviceable, and in time they may be improved. Implements and machines are rapidly taking the place of many hand-tools, but because of their cheapness hand-tools will be used by many farmers for years.

Implements. In certain districts of the Philippines, the farmers cut and burn the vegetable growth on the soil and then till the soil with a long, sharp stick. An iron-pointed wooden plow, drawn by one carabao or bullock, is used in other districts. Large steel plows fastened together and drawn by a steam or kerosene engine also are used on large modern farms. Most farmers till the soil by using iron or steel implements that are drawn by animal or other power. It is the proper use of these implements that we should learn.

Plows. Plows may be divided into two classes: *mold-board plows* and *disk plows.* Moldboard plows turn the soil over with the moldboard, while disk plows turn it over with

FIG. 20. A good plowing outfit for heavy soils.

the disk. Some moldboard plows are made especially for heavy soils, and others are better in light soils. The "Mindoro" plow is especially adapted to soils of a sticky or clayey nature because its moldboard scours well in such soils. A plow with a wide, sharply curved moldboard is adapted for light soils. It will turn the soil and break it up fine. For breaking sod land for the first and second plowing or to use in heavy soil, a 30-centimeter plow of the Prairie Queen type is suitable (Fig. 20).

In some soils a disk plow works better than a moldboard plow. With a disk plow, it is not necessary to clear off long grass, as the disk cuts the sod and turns it over. A moldboard plow will turn soil that is too hard for the disk plow to enter. The disk plow is easier on the animals and on the plowman also, as he rides on the seat and keeps the plow adjusted with the levers. A plow with an extra large disk that is kept sharp, is excellent for turning under green manure. The point of a moldboard plow and the disk of a disk plow should be kept sharp.

In the Philippines it is customary to till the soil with a

wooden plow which has an iron point. The advantages of this tool are that it is cheap, light, and can be drawn by one animal. It requires frequent adjustment, however, when used

FIG. 21. An iron Philippine plow.

on rough ground, and does not till the land deep enough to allow good crops to be raised. The modern plow is heavier and more expensive, but the farmer can plow more land with it in a day and the work will be better done.

Using the plow. When two animals are worked together, they will do more work and will be more easily controlled if placed side by side. When four animals are used, they should be hitched in pairs. The two animals ahead should be attached to the plow and not to the animals behind.

To get the best results, a farmer must pay strict attention to the proper adjustment of his plow. If it runs too deep, lower the clevis or shorten the trace, or do both; if too shallow, raise the clevis or lengthen the trace, or do both. If the plow makes too wide a furrow, shift the clevis toward the unplowed land; if the furrow is too narrow, shift the clevis

toward the plowed land. The farmer should know the name and use of each part of a plow; he should also know how to put the plow together and how to adjust it. When not in

FIG. 22. A harrow with an iron frame and spike teeth.

use, a plow should be kept free from soil. The bright parts should be covered with grease or oil, the wooden and other parts painted, and the plow stored in a dry place.

Selecting a plow. In purchasing a plow, the following points are to be considered: first, whether the land to be plowed is heavy or light; second, the amount of land to be tilled; third, the number of animals to be used; and fourth, the kind of crop to be grown.

The harrow. The harrow is used to break the clods on land that has been plowed and to make the topsoil fine and smooth for the planted crop. This can be done best before the clods have time to become hard. For this reason, land that is plowed in the morning should be harrowed the same

day. Breaking the clods exposes the roots to the sunshine and thus kills any weeds that may be growing in them. Just before corn plants are up, the soil is sometimes harrowed to make a soil mulch and to kill weed seedlings.

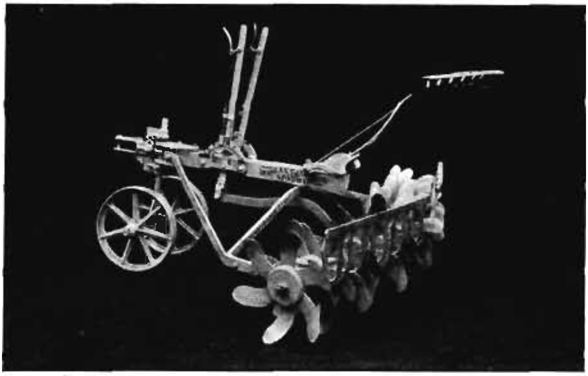


FIG. 23. A spading harrow, a good implement to break clods and cut sod.

A harrow usually has an iron or a wooden frame. A very good one can be made of bamboo or of bamboo and iron. The harrow commonly used in the lowland rice fields is shaped like a comb. It is drawn through the muddy plots to break the clods and to bury the green grass and other vegetable matter.

Cultivators. Cultivators are used to loosen the soil and uproot weeds between rows of growing crops, as corn, sugar-cane, tobacco, and cassava. A modern cultivator can be made wide or narrow so as to be used in either wide or narrow rows. The depth of cultivation also can be regulated. Some cultivators are pushed by hand; others are drawn by one or two animals. Cultivators differ from plows in that they only

loosen the topsoil; they do not turn it over. If a farmer has a field of plants growing during the dry season, he should keep the topsoil loose. The soil should be tilled 6 centimeters deep every few days. One man and an animal with a suitable cultivator can till as much soil as several men can cultivate by using hoes.

Farm machinery. Farmers in different parts of the world have machines that can do the work of many men. There are machines that plow several hektars in a day. Machines are also used to plant, harvest, thresh, and hull rice. Corn is planted, harvested, husked, shelled, and ground by machines. Tobacco plants are set out, water is lifted, and many other kinds of farm work also are done by machinery. As a rule, machines are expensive and can be used profitably only under certain conditions. One man might purchase a machine and make money with it, while another with a similar machine might lose money. There are four conditions that must be right before a machine can be used with profit: first, the machine must be a good one of its kind; second, it must be suited to the work at hand; third, the operator must know how to use it; and fourth, if the machine is an expensive one, the farmer must have considerable work for it to do. When all these conditions are favorable, a farmer who uses modern machinery will be able to increase his crops and make a greater profit from his farm. Before a farmer invests his money in a machine, he should be reasonably sure that the investment will be profitable to him.

Carts. A two-wheeled vehicle for carrying loads is called a *cart*. There are many different kinds of carts. Practically all vehicles in the Philippines, either for passengers or for freight, are carts drawn by a horse, a carabao, or a bullock. A

modern cart has a fixed solid-steel axle, to each end of which is attached a wheel. To prevent the axle from wearing and to make the wheels turn easily, the axle should from time to

FIG. 24. A cart-load of coconuts.

time be wiped clean with a rag and should have a little castor oil or other oil applied to it. When a cart is not in use, keep it under a roof and paint it every year or so.

Carts used on first-class or improved public roads in the Philippines must be equipped with wheels having tires 6½ centimeters or more in width and with wheels which turn on the axle. The use of sleds and narrow-wheeled carts on these roads is prohibited by law. The reason is that these vehicles have a tendency to cut the surface of a road. It is costly to construct and maintain good roads, and any practice that needlessly destroys them must be prohibited. The provincial board designates which roads are improved, and any person who violates the law is liable to a heavy fine.

Wagons. In districts where the roads are improved, four-wheeled vehicles called *wagons*, drawn by two or more ani-

mals, are coming into use. Where much hauling is to be done, it is more profitable to have one man drive two or

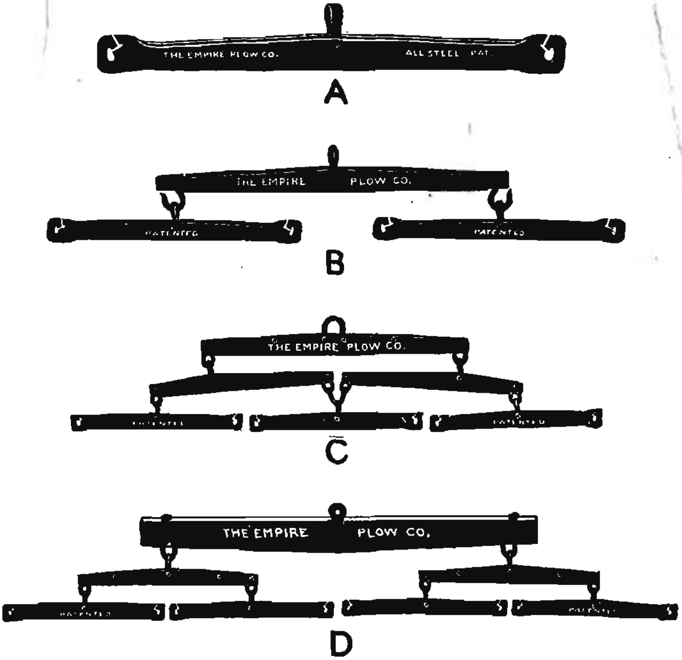


FIG. 25. *A*, a singletree, for harnessing one animal to a load; *B*, doubletree and two singletrees, for two animals; *C*, one doubletree and three singletrees, for three animals; *D*, one doubletree and four singletrees, for four animals.

more animals drawing a good load, than to have one man drive one animal with a small load.

Sleds. A vehicle on runners, for drawing loads through mud and over mountain trails and rough places, is called a *sled*. Sometimes one end of a log is placed on a sled and then drawn by either man or animal power. A short canoe or

dugout drawn by a carabao makes an excellent sled for drawing loads through soft mud.

Care of farm implements. What is worth having is worth taking care of. After using a tool, implement, machine, or

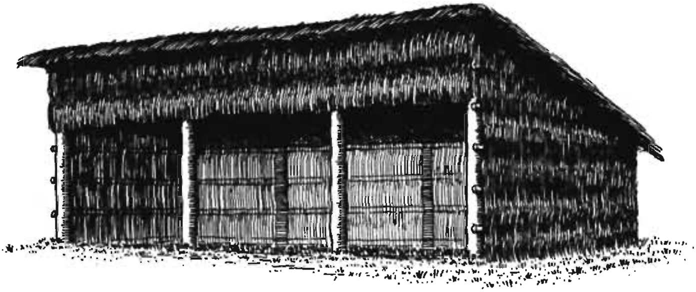


FIG. 26. A shelter for carts, wagons, and farm machinery. The opening should face away from the winds that prevail during the rainy season.

vehicle, clean it and put it away where it will be protected from the rain and the sun. The parts that are iron should be kept covered with paint or oil to prevent them from rusting. This applies to all tools, implements like plows and cultivators, sugar machinery, and farm vehicles. The wooden parts of tools and implements should be painted.

The repair shop. If any part of a plow, harrow, cultivator, cart, or any other implement, machine, or vehicle, becomes loose, adjust it immediately before it breaks. The old saying, "A stitch in time saves nine," is a good one for the farmer to remember. Many tools and machines can be prevented from breaking and will last for years if used as intended and kept properly adjusted.

For making repairs, a large farm needs a repair shop. It should be under a permanent roof that will furnish a dry, comfortable place to work in on rainy days.

The equipment of the repair shop. The number of tools and the amount of supplies kept in the repair shop depend largely upon the number of implements used on the farm. With a few carpenter tools, such as a saw, hammer, brace and bits, chisels, and a monkey-wrench, a small farmer can make and repair many of his own tools. As a rule, it will be cheaper for him to have all iron-work done by the town blacksmith. But on a large farm where considerable machinery is used, it will be more economical to have, besides a supply of tools for work in wood, the following equipment for work in iron: a good forge, an anvil about 65 kilos in weight, several different shapes and sizes of tongs, a sledge hammer, hand-hammers, drill-press, and sizes of drills by sixteenths of an inch from three-sixteenths to one inch, different sizes of monkey-wrenches, a few bars of tool-steel for making punches, chisels, and other tools, together with a stock of iron that may be secured according to the needs for repairs.

Each farmer must determine what equipment is necessary for his shop. A good general rule to follow is to keep on hand several pieces of well-seasoned wood, some bamboo and rattan, together with extra plow-points, plow-beams, yokes, singletrees, and other articles that he commonly uses in his work.

Care and repair of tools. Tools, as well as implements, should be kept in a dry place and oiled from time to time to prevent them from rusting. Keep sharp-edged tools, such as chisels, saws, bits, and adzes, in a chest. Have a separate place for each tool so that its edge will not be dulled by rubbing against other tools.

Making repairs promptly. If a tool, implement, machine, or vehicle breaks while in use and there is no other one to use in its place, repair it immediately either by mending the broken

part or by exchanging it for a new part from the repair shop. Whenever possible, the repair work should be done on rainy days or on days when there is no field work to be done.

EXERCISES

Exercise 8. To make a list of necessary farm equipment. Have each pupil prepare a statement of how he would expend ₱1000 in erecting buildings and purchasing equipment for a farm of 16 hektars. Make a map of the farm, indicating crops grown on each field. Have the cost of each building, implement, tool, or animal listed separately. The list should include everything necessary to operate the farm.

Exercise 9. To show the effect of rust on iron or steel. Get a piece of iron that is beginning to rust and one that is badly rusted. Note the effect of the rust on the metal. If a microscope is at hand, allow the class to examine with it a rust spot on the edge of a knife or razor. What effect has rust on the life of steel implements and tools?

Exercise 10. To demonstrate that oil protects iron or steel against rust. Take two pieces of well-polished iron or steel and cover the surface of one of them with oil. Do not place anything on the surface of the other. Store them together in a dry place. After three months, examine them again. Wipe off the grease and see which piece has the brighter and smoother surface. This exercise can best be conducted when the pieces of iron are stored through a rainy season. How may tools and implements be protected from rust?

Exercise 11. To demonstrate the effects of exposure to the weather on iron or steel. Repeat Exercise 10, but expose the pieces of metal to the weather for one month. What can be learned from this exercise that applies to the care of tools and implements?

CHAPTER V

THE SOIL

FIG. 27. A flood plain, where alluvial soil has been deposited by the river.

THE soil is the farmer's bank, from which, by the aid of plants, he draws his wealth. Hidden away in his fields there are stores of treasure that the crops can gather for him through their roots.

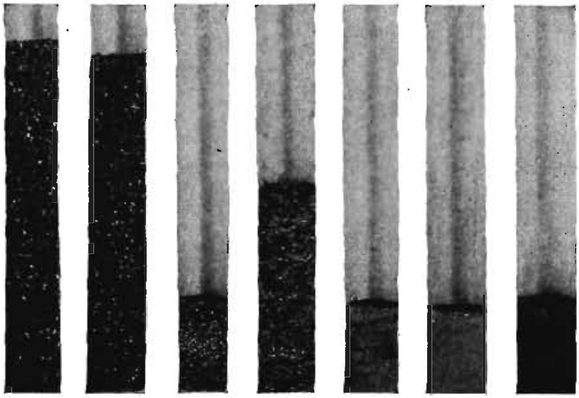
What is this material that we call the soil? How does it feed the farmer's crops? What can the farmer do to guard its riches and save them for his own use? These questions we shall discuss in this chapter.

Mineral and vegetable matter. Soil is composed of mineral matter and vegetable matter.[1] The mineral matter consists of decaying rocks. The vegetable matter consists of decaying plants. The mineral and the vegetable materials are thoroughly mixed together.

[1] The soil also contains animal matter from decayed animals, but the amount is very small as compared with the large amount of vegetable matter present.

Mineral matter in the soil. The mineral matter in soil includes gravel, sand, silt, and clay. The largest pieces are called gravel and the smallest ones clay.[1]

Gravel consists of small stones, such as are found in the beds of rapid streams. The ocean beach in some places is



1 *2* *3* *4* *5* *6* *7*

FIG. 28. The amounts of each of the different kinds of particles found in a sandy soil: *1*, fine gravel; *2*, coarse sand; *3*, medium sand; *4*, fine sand; *5*, very fine sand; *6*, silt; *7*, clay. Note that the coarser particles make up a large part of this soil.

composed largely of gravel. Gravel is excellent for building roads.

Sand is composed of rock particles smaller than gravel. It can be found near a river or the ocean. According to the size of the particles, sand is classed as coarse sand, medium sand, fine sand, or very fine sand.

Silt is composed of rock particles that are smaller than those in sand, but larger than those in clay. Mud or fine soil which

[1] Get a handful of clay, one of silt, one of sand, one of gravel, and a stone, and arrange them in order of fineness.

is deposited from slowly moving water contains a large amount of silt. Silt feels like flour when rubbed between the thumb and the finger. River water is usually muddy after a heavy rain, owing to the large number of silt and clay particles suspended in it.

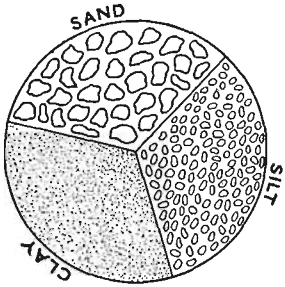


FIG. 29. A diagram to be used in illustrating enlarged particles of sand, silt, and clay. (See Exercise 14.)

Clay is composed of very fine particles of rock. When fine clay is rubbed between the thumb and finger, it feels slick. It is not gritty. The particles of rock in clay are as small as the particles of chalk in chalk dust. Clay is used to make rice-pots, stoves, tiles, bricks, and water-jars.

Different kinds of soils.[1] A soil that contains considerable sand is called a *sandy soil*. It falls apart easily. Even when it is very wet it does not become sticky, and when it is dry it does not form clods.

A soil that contains considerable clay is called a *clay soil*. It is hard when dry and very sticky when wet.

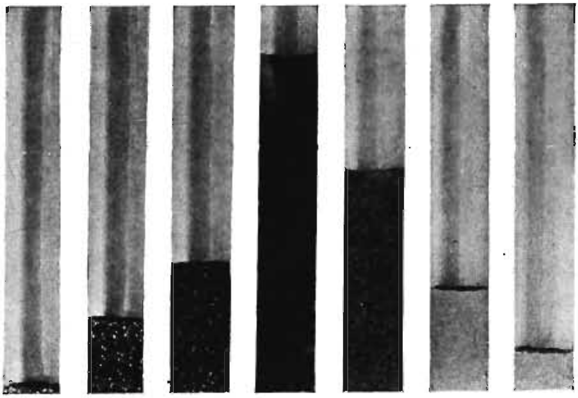
A soil that is neither loose enough to be classed as sand nor sticky enough to be called a silt loam or clay loam is either a loam or one of the sandy loams.

Vegetable matter in the soil. Fertile soils contain large amounts of vegetable matter. This matter consists chiefly of small pieces of decaying plants. It makes the soil dark

[1] According to the way that soils feel they are classed as:

coarse sandy soil	medium sandy loam	clay loam
medium sandy soil	fine sandy loam	silty clay loam
fine sandy soil	loam	clay
coarse sandy loam	silt loam	

in color and also makes it loose. The little fragments of vegetable matter hold water like little sponges and give it up to the growing plants in time of drought. One



1 *2* *3* *4* *5* *6* *7*

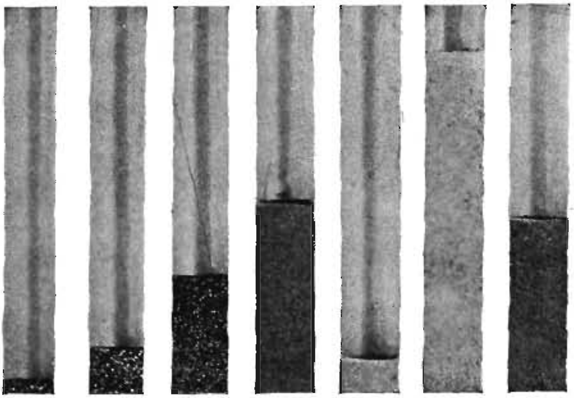
FIG. 30. The amounts of each of the different kinds of particles found in a loam soil: *1*, fine gravel; *2*, coarse sand; *3*, medium sand; *4*, fine sand; *5*, very fine sand; *6*, silt; *7*, clay. Particles of medium size are most abundant in this soil.

hundred kilos of rich soil contains about five kilos of vegetable matter.

Porous and impervious soils. In porous soils, the spaces between the particles are large enough to allow the air and water to pass freely through them. Sandy soils and soils rich in vegetable matter are porous. A soil of this kind is loose and plows easily. The farmer calls it a light or *friable soil.*

An impervious soil prevents water from passing through it. The spaces between the soil particles are so small that water does not pass through them. Impervious soils are usually fine clays that lack vegetable matter. Such a soil is *heavy* and hard to plow. Cultivating a clay soil when it is too wet

causes it to bake when it dries. The particles then form a very hard mass. Good soils for lowland rice usually have an almost impervious clay beneath the surface soil.



1 *2* *3* *4* *5* *6* *7*

FIG. 31. The amounts of each of the different kinds of particles found in a clay soil: *1*, fine gravel; *2*, coarse sand; *3*, medium sand; *4*, fine sand; *5*, very fine sand; *6*, silt; *7*, clay. A clay soil is composed in large part of fine particles.

Sometimes land with an impervious subsoil is divided into fields by dikes and flooded to form fish ponds. Fish farming may be as profitable as other farming. There is no reason why raising fish should not pay as well as raising pigs or chickens.

Topsoil and subsoil. The upper layer of soil (topsoil) contains considerable vegetable matter. The soil under this top layer (subsoil) contains less vegetable matter and is lighter in color. The difference in the color of topsoil and subsoil may be noted along river banks.

Alluvial soil. After a heavy rain the water in the creeks and rivers is usually muddy. The rivers are carrying the

FIG. 32. Repairing the dike on a fish farm. On some farms with impervious subsoils fish can be raised and marketed with profit.

soil away. Mud is composed mostly of clay and silt mixed with vegetable matter and is found either along the banks of slowly moving streams or on land where it has been deposited during floods. It usually contains a large amount of food materials for plants. Soil that has been carried by rivers and deposited along their banks is called *alluvial soil.* The low, level lands in the Philippines are usually composed of alluvial soils (Fig. 27).

What effect has the swiftness of a river upon the size of the soil particles that it can carry? When do rivers move gravel? When do they deposit it? When do they move and deposit sand? silt? clay? Do rivers separate the small particles from the large ones? What effect do winds or volcanoes have upon soil? Does wind move sand along the beach?

Colluvial soil. Soil along a steep hillside or mountain slope is usually formed from materials that were brought

from places higher up. It is composed of stones, gravel, sand, and finer particles, all mixed together, and is called *colluvial soil.* It is moved by earthquakes, wind, and water. Colluvial soil often causes considerable damage to mountain trails and roads.

Color of soils. Soils that contain the most vegetable matter are as a rule darkest in color, but some soils are dark because they contain certain minerals. Stiff clay soil has a small amount of vegetable matter; subsoil has less than topsoil; and beach sand has practically no vegetable matter in it.

Bacteria in the soil. Bacteria are very small living plants that are found in the soil. So abundant are they that there may be 10,000,000 of them in a single gram of fertile soil. The topsoil contains many more bacteria than the subsoil.

Bacteria the cause of decay. Certain of the soil bacteria feed on matter like the leaves, stems, and roots of plants, and cause them to decay. The process of decay can be seen all about us in house-posts at the surface of the soil, in sods or leaves piled together, and in logs and stumps.

Good and bad soil bacteria. The soil is the home of many different kinds of bacteria that, as far as plant growth is concerned, may be divided into two classes: first, those that are beneficial to plant growth; second, those that are harmful to plant growth. If soil is too wet, or too compact, or lacks vegetable matter, or is somewhat sour, the injurious bacteria multiply rapidly and for some reason the plants do not grow well. On the other hand, if the soil has just enough and not too much water, air, lime, and vegetable matter, the beneficial bacteria multiply rapidly and the plants in turn grow luxuriantly. Bacteria assist plants to secure food materials from both the air and the soil.

Air spaces between the soil particles. Make a pile of small stones; also piles of gravel, sand, silt, clay, and decaying vegetable matter. What is in the spaces between the small stones? Is there air between the pebbles of gravel? Is there air between the grains of sand? Is there air between the particles of silt? Is there air between the particles of clay? Is there air between the particles of vegetable matter?

All soils contain air spaces. The larger the soil particles, the larger are the air spaces. In ordinary soils, silt is found in the spaces between the grains of sand, and clay in the spaces between the particles of silt. The more clay there is in a soil, the smaller the air spaces. The more sand and vegetable matter there are in the soil, the larger the air spaces.

Air necessary for the roots of plants. The roots of most plants, like men and animals, must have air. If the air spaces between the soil particles are filled with water, the roots of the plants drown. It is necessary, therefore, that farm land be well drained so that the roots can have a supply of air.

Good and poor soils. A fish lives in water, an earthworm burrows in the earth, a monkey lives in trees, and a deer hides in the grass. Each animal is fitted to live in a different home. In the same way, different kinds of plants are fitted to grow in different soils. A crop may flourish in one soil and fail to grow well in another soil. A soil that is good for nipa is poor for sugarcane. Mango, corn, sugarcane, tobacco, and coconuts grow well on loam soils that are well drained. Sweet potatoes, peanuts, watermelons, and garden vegetables grow best on sandy soils. A farmer must study the soil on his farm and plant the crops that will grow best on it. He will be working against nature if he does not fit his crops to his land.

EXERCISES

Exercise 12. To demonstrate soil particles. Weigh out a gram of soil that produces a good crop of rice, tobacco, or sugar-cane. Place it in a clean, clear-glass bottle, add water, cork the bottle, and shake it thoroughly. You can see that the soil contains many small particles. There are said to be about 10,000,000 of them in one gram. Set the bottle away. How many days does it take for the clay to settle completely?

Exercise 13. To separate the sand, silt, and clay particles in a soil. Place a spoonful of sandy soil in a large glass tumbler filled with clear water and stir the soil and water with a stick until the particles of soil are thoroughly mixed with the water. Stop stirring and after one minute carefully pour off the muddy water into a clean basin. Again fill the tumbler with clear water, stir the soil, and after waiting one minute again pour off the muddy water. Repeat this five or six times, or until the water poured off is quite clear.

Most of the soil that remains in the tumbler is sand. The particles are so coarse that they do not float in the water. Rub the sand between the thumb and finger. It is gritty.

Allow the muddy water to settle for twenty-four hours. Then carefully pour it off, leaving the sediment in the bottom. This sediment is the silt. Rub it between the thumb and finger. It is finer than the sand and feels like flour.

Evaporate the water in a vessel over a fire. The fine clay particles remain. Rub them between the thumb and fingers. Why do the silt particles settle before the clay?

Exercise 14. To illustrate how soils may be compared as to varying quantities of sand, silt, and clay. Copy Figure 29 on the blackboard. Then cut a circular opening in a piece of cardboard and hold it over the drawing so that a large amount of the clay and silt will show, and only small amounts of the sand area. Such a soil would be called a clay soil. Shift the paper about and illustrate

the composition of a sandy soil, a loam, a clay loam, and a sandy loam. It will be seen that, according to the varying amounts of the sand, clay, and silt in them, different kinds of soil will grade insensibly into each other. Soils composed entirely of one kind of particles are not found in nature.

NOTE. Discuss the kinds of soils best suited to the principal crops of the region. If different types of soils are found in the region, discuss these types and make excursions to where they are to be found. Impress on the class the importance of selecting crops that are suited to the soils on which they are planted.

Exercise 15. To compare the physical properties of different soils. Obtain samples of clay, loam, and sand soils. Note the feel of each between the fingers. Wet a handful of each and work it together with the hand. Which is stickiest? Which falls apart most easily when dry? Which sticks together after drying? By walking over a field, especially after it is plowed, and feeling the soil here and there, one can easily determine the kind or kinds of soil. Make a map of some farm and by different colors locate on the map the clay soil, the sandy soil, and the loam.

Exercise 16. To demonstrate the rapidity with which water enters different soils. Take four bamboo tubes (pots without joints) and four half coconut shells (Fig. 33). Tie a piece of thick cloth over one end of each tube. Fill the first tube with coarse dry sand; the second with fine dry loam; the third with fine dry clay; and the fourth with clay and fine dry vegetable matter, half and half, thoroughly mixed. Tap each tube on the table several times to pack the soils, and then arrange the tubes as shown in Figure 33.

Fill a long-necked bottle with clean water. Now, with watch in hand, pour water into one tube as rapidly as it sinks in, and keep pouring slowly till water drips from the bottom. How long does it take the water to pass through? Keep a record of this time. Pour

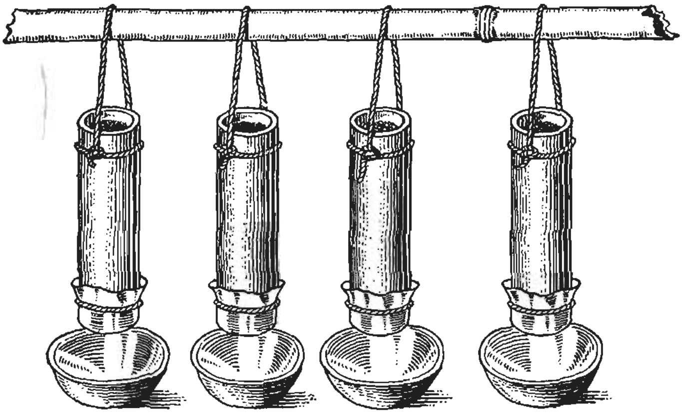


FIG. 33. Bamboo tubes and half coconut shells, as used in Exercise 16.

water into the other tubes, and keep a record of the time it takes to pass through. Which soil is most porous; that is, which allows water to enter and to pass through most quickly? Which soil is most impervious; that is, which will not allow water to enter and to pass through quickly? If you have two fields, one of clay and the other of clay and vegetable matter, from which field will the rain water run off on the surface? Which field will allow more of the water to sink into the soil? How can a clay soil be made porous?

Exercise 17. To test the comparative fertility of topsoil and subsoil. Dig a hole 50 to 100 centimeters deep and take a quantity of soil from the bottom of the hole. Fill a bamboo pot with topsoil taken at the top of the hole. Fill another bamboo pot with the subsoil from the bottom of the hole. Plant 3 kernels of corn in each pot. Water the pots when needed. Give them good care. Compare the plant growth twice a week for six weeks. Make proper entries of the observation on a chart and in notebooks. Discuss the relation of this exercise to Exercise 7 (page 26).

Exercise 18. To show that air occupies space. Take a large, clear-glass bottle and push it mouth downward into a jar of water.

Does the water enter the bottle? Why? Tip the bottle a little to let out some of the air. Does water enter the bottle? The more air escapes from the bottle, the more water enters the bottle. When the air has entirely escaped, the bottle fills with water. Air and water cannot occupy the same space at the same time.

Exercise 19. To show that water drives air out of soil. Place your hand over one end of a lamp chimney and fill the chimney with gravel. Then add water quickly. The air escapes as the water enters. Now let the water escape slowly from the bottom of the chimney. As the water escapes below, the air enters from above. This exercise illustrates the great principle in drainage.

Exercise 20. To measure the amount of air space in a soil. Measure out a liter of coarse dry sand. Pour it into a tall, narrow vessel (a bamboo pot may be used). Pour water on the sand from a bottle until the air between the particles is driven out and the spaces are filled with water. The amount of water used from the bottle is equal to the air spaces in the soil. How many cubic centimeters of water were used? There are 1000 cubic centimeters in one liter. What per cent of the liter of sand is air spaces?

Exercise 21. To prove that air is necessary for the growth of roots. Place water in a clear-glass bottle and insert a sweet potato cutting. Add enough coconut oil to cover the surface of the water. The oil prevents air from entering the water. Fill a second clear-glass bottle with water and insert a cutting similar to the one in the first bottle. Set both bottles in the window and observe the growth of the roots in the water.

CHAPTER VI

WATER AND FOOD MATERIALS IN THE SOIL

An ordinary farm plant has its roots in the soil; its leaves are a deep green; it is vigorous and growing rapidly. Then some one cuts the plant down. It is separated from its roots, and the plant quickly withers and dies.

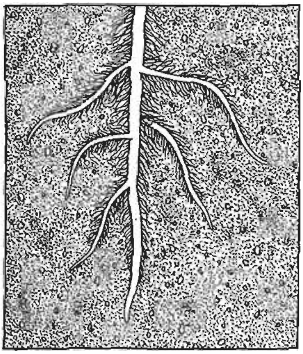


FIG. 34. Showing how the roots of a plant push their way into the soil.

What does a plant get from the soil? Its roots grow deep down into the earth. What do they bring up for it? How does cultivating the soil help the farmer's corn or sugarcane? How does manure benefit his crops? To answer these questions we must understand how a plant lives.

Plants get water from the soil. The roots of a plant grow down into the earth and take in water (Fig. 34). This water then passes up through the stem to the leaves. Without a continual supply of water, a plant cannot make the best growth, and a plant that is cut down withers because its water supply fails. *A plant gets water from the soil.*

Water in the soil. In a very wet soil the space between the particles is filled with water. When a soil is drained, the *free water* that is between the particles runs off; but a thin film, or coat, of water is left on each soil particle. This film water forms a store of moisture in the soil for the farmer's plants. The finer a soil is, the greater is the total surface of its particles

and the more water it will hold. For this reason, clay soil will hold more water than sandy soil.

How water leaves the soil. There are three ways by which water may leave the topsoil. It may run away on the surface into the creeks and rivers; it may sink into the earth; or it may evaporate[1] into the air. These may be called the run-away, sink-away, and fly-away methods of leaving the soil.

During the rainy season, surface drainage removes large quantities of water very rapidly from the land. Unless his land is rolling or very porous, a farmer must carefully ditch it to assist the surface water to drain during heavy rains; for if water is not quickly removed, it will drive the air out of the soil and the roots of the plants will be injured.

The water that sinks into the soil finds its way into creeks or rivers, or it may flow into the ocean as an underground stream. A spring is a place where this water flows out again on the surface of the land. The water in an artesian well comes from an underground supply. In land that has a subsoil of sand or gravel the water may sink rapidly down beyond the reach of the roots and be lost. In the dry season the water in the soil is lost mainly by evaporation. Part of it evaporates directly from the soil into the air, and part of it is taken up by the plants and evaporates from their leaves. Cultivating the land prevents the soil water from escaping by evaporation and also kills weeds that are taking the water that should be left for the crop plants.

How a plant gets water from the soil. The fine hairs on the root of a plant grow in among the particles of the

[1] When water evaporates it changes into vapor and passes off into the air. Water that is boiled in a vessel gradually evaporates.

soil.[1] The water on the surface of the soil particles then passes into the hairs, on into the vessels of wood in the center of the root, and up through the vessels to the stem and leaves of the plant. Dig up a handful of soil near a corn plant and you will find it filled with fine roots. These send millions of root hairs all among the soil particles, and through these hairs the roots take in the water that is in the soil.

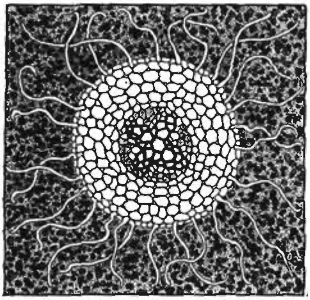


FIG. 35. Cross-section of a root. The root hairs absorb the water, which passes into the vessels that are shown in the center of the root.

The importance of a good water supply for plants. With a proper water supply the farmer's crops are almost sure to flourish. With too much water or not enough water, his crops will fail, no matter how rich his land may be. By drainage, by irrigation, and by soil and vegetable mulches, the farmer can assist his plants to get the amount of water that they need. This is the most important point in the growing of plants.

A *desert* is a place where the soil is usually dry. Few plants grow there. A *swamp* is a place where the soil is full of water. Some plants, like nipa and lowland rice, can live in swamps, but most agricultural plants do not grow well in the mud. Their roots die when they are shut off from the air. Where the topsoil is moist during all or a greater part of the year, agricultural crops will grow. In some countries the best farm lands are made by draining swamps and irrigating

[1] For a discussion of the structure of roots and root hairs the reader is referred to Book I.

deserts, for the soil is excellent for agriculture if only the supply of water is controlled.

Plants get food materials from the soil. *A plant gets food materials from the soil and from the air.* Plants require the following ten different materials for growth: iron, sulfur, potassium, calcium, magnesium, phosphorus, nitrogen, carbon, oxygen, and hydrogen. The first seven of these are taken from the soil; the remaining three from water and air.[1] When the plant is burned, all the materials that are taken from the soil, with the exception of nitrogen, remain in the ash. The nitrogen escapes into the air. How many food substances are found in the ash? Name them.

The foods in the soil are dissolved by the soil water, enter the roots, and pass up with the water into the plant. Put some salt in a bottle of water and shake the bottle. The salt dissolves. In the same way the soil water dissolves the minerals in the soil particles. The ash from burned plants is composed of minerals that the plants have taken up from the soil.

How food materials are lost from the soil. There are four ways by which food materials are lost from the soil:

1. They are lost from the soil in the surface water which flows into streams and rivers. The salt in the ocean was carried down into it from the soil. When the topsoil itself is washed or blown away, much valuable food is lost with it. The fertile lands along rivers often contain plant foods carried down from the hills above and deposited on the lowlands during a flood.
2. In porous soils food materials are lost in the water that sinks into the earth. Much valuable food material is

[1] *Legumes are able to take nitrogen from the air.* See Book III.

lost in this way in sandy soils and where the subsoil is composed of gravel. To maintain the fertility of such soils, manures must be added frequently.

3. Food materials are lost when crops are removed from the fields. When a crop of tobacco, abacá, rice, or coconuts is sold, the materials that are in them are lost from the land.
4. When plants are burned, nitrogen is lost and valuable vegetable matter is destroyed.

Food materials that may be lacking in the soil. If one of the ten food substances cannot be secured by a plant in the proper amount, the plant will not develop as it should; if the material is entirely absent, the plant will die. The foods that are most commonly lacking in the soil are *nitrogen*, *phosphorus*, and *potassium*. These are supplied in manures, or they may be purchased in certain substances called *fertilizers.* In fertilizers, phosphorus is usually purchased in the form of a substance called phosphoric acid, potassium in the form of a substance called potash, and nitrogen in the form of mineral salts called nitrates. In Manila phosphoric acid costs about 25 centavos a kilo and potash about 28 centavos a kilo, when purchased in fertilizers. Nitrogen costs about 90 centavos a kilo.

In the next chapter we shall study more in detail the question of adding food materials to the soil.

EXERCISES

Exercise 22. To determine the amount of free water and film water held by different soils. Take 3 bamboo tubes 20 centimeters long and of about the same size. Tie a piece of thick cloth over

one end of each (Fig. 33). Fill the first tube with dry gravel, the second with dry sand, the third with dry clay. Weigh each tube and keep a record of the weights. Stand the tubes in a can, and add water until it is even with the soil in the tubes. After 48 hours lift the tubes from the water and immediately hang them on a pole over the shells as shown in Figure 33. The water that drips into the shells is the free water. After all dripping has ceased, weigh or measure the water in each shell. From which soil was the greatest amount of water obtained?

Weigh each tube, and, by comparing this weight with the dry weight, determine how much film water is held by each soil. The difference in each case represents approximately the water that surrounds the soil particles. What proportion of the dry weight of the particles is it? Does the fine or the coarse soil hold more film water?

NOTE. After the soil is drained in this way some of the small spaces between the particles are still filled with water. None of the water retained by the soil, however, is free water.

Exercise 23. To determine the amount of water in moist soil. Get moist soil from a field and weigh out 200 grams. Spread it out on a paper in the sun to dry. Weigh it again. The loss in weight shows the weight of the water that the moist soil contained. This water is called *film water*. It surrounds the soil particles, and the food materials are dissolved in it.

Exercise 24. To determine the amount of water and ash in plants. Take a large corn plant, a rice plant, or any other juicy green plant and weigh it. Write the weight in your notebook. Place the plant in the sunshine until it becomes perfectly dry. Weigh it again. The difference in weight is due to water lost in drying. Touch a match to the dry plant, which will soon be reduced to ashes. Carefully weigh the ashes. What is lost in burning is largely carbon. Write the results as follows:

	Weight
Water lost by drying in the sun	
Matter lost by burning (composed of carbon, oxygen, hydrogen, and nitrogen)	
Ash that remained	
Total	

The total of these weights should be equal to the weight of the green plant.

How many food materials are found in the ash? Name them.

CHAPTER VII

MANURES AND FERTILIZERS

FIG. 36. Hauling manure to the field.

"*A rich soil makes a prosperous people.*" This is a true statement, but it is not easy to keep a soil rich. The most fertile lands become worn out by cropping unless vegetable matter and food materials are returned to them. In time the vegetable matter will disappear, and the supply of certain food materials that the plants use will also be exhausted. Then the crops will grow but poorly, and the farmer will gain little profit from his work.

The intelligent farmer does not rob his land. He does not draw all the riches from his soil bank, but year by year keeps returning to the land as much food material as is removed. In this way his crops are made to flourish, and he gets a good profit from his farm. In this chapter we shall study how to maintain or increase the fertility of the soil.

Increasing the fertility of a soil. Soils are made fertile by adding to them farm manure, green manure, compost, tankage, guano, and other organic matter.[1] Wood ashes and lime and certain strong manures called fertilizers also are used to enrich the land. Any material which is added to the soil to increase the vigor or productiveness of plants is called a *manure* or a *fertilizer*.

FIG. 37. A practical farmer carrying manure to his rice field. He has learned by experience how to increase his crop of rice and sweet potatoes.

How manure improves the soil. Certain manures increase the vegetable matter in the soil. This increase improves the soil in three ways:

First, it adds very greatly to the water-holding capacity of the soil. There may be 10 kilos of vegetable matter in 100 kilos of rich soil, and this vegetable matter will hold more than its own weight in water. In the vegetable matter in a rich soil there is a great store of water that the plants can draw on during the dry season.

Second, vegetable matter makes a soil looser and more porous. This allows the air to reach the roots of the plants easily, it makes the soil warmer, it prevents the soil from washing, and it makes it easier to cultivate.

[1] An explanation of these terms will be found in later paragraphs of this chapter.

Third, decaying vegetable matter furnishes food materials to the plants. When the vegetable matter decays, food materials are formed which the roots of plants take up.

Farm manure. From the beginning of agriculture, farm manure has been one of the important means of maintaining and increasing the fertility of the land. It furnishes the soil with certain plant foods. The dung and urine of domestic animals, either alone or mixed with straw, grass, sand, or other litter, is called *farm manure.* The dung of cattle, carabaos, and horses is largely vegetable matter. The urine from these animals contains more nitrogen than the dung and should be carefully saved. The manure produced in a year by different farm animals in the Philippines is estimated to have the following average values: [1]

horse	₱ 54.00
carabao	50.00
bullock	38.00
hog	12.00
sheep	4.00
goat	4.00
hen	.50
duck	.50

Saving farm manure. In many cases the farmer considers the manure from his animals a nuisance. He throws it away or burns it. When he does this he makes a mistake. It should be put into the compost pit or spread on the land and worked in with the soil. Then it will feed the crops that are grown on the land. If manure is piled and exposed to the

[1] The value of the manure has been arrived at by calculating how much the food materials in it (nitrogen, phosphorus, and potassium) would cost if they were purchased in the form of fertilizers in Manila.

FIG. 38. A field of velvet beans, which are a good green manure crop. Let the hogs do the harvesting; then turn under the vines.

rains, the food materials in it will be dissolved by the water and carried away. It should, therefore, be spread on the fields and worked into the soil as soon as possible.

Green manure. Green plants plowed under soon decay and add both vegetable matter and food materials to the soil. Matter of this kind is called *green manure.* In many countries it is a common practice to raise green manure crops and plow them under. Legumes (for instance, cowpeas) make the best manure crops, for they are rich in nitrogen. Ordinary legume plants get about one third of their nitrogen from the soil and two thirds from the air; thus when they decay there is added to the soil more nitrogen than the soil contained before they grew. When other plants decay, they add to the soil only the amount of nitrogen that they took from it.

Compost. When leaves, grass, dung, and soil are mixed together and allowed to decay, a manure called *compost* is

formed. Compost is sometimes made by placing these materials in a hole, or pit, dug in the soil. Excellent compost is made by placing vegetable matter and soil in layers. After a few months the vegetable matter will decay and then the compost is ready for use. It should be applied to the soil like other farm manure.

Compost pit. A compost pit can be made by digging a hole or pit 2 meters deep and 1½ meters square. Pile the removed dirt near the edge of the pit to keep water from running from the topsoil into it. Plaster the bottom and sides of the pit with clay to prevent the liquid in the compost from escaping. Sod, leaves, grass, and other vegetable matter that will decay easily should be thrown into the pit. During the dry season water should be added from time to time. Peanut and mungo plants make good compost. Manure from horses, cattle, goats, and other animals, together with ashes from the kitchen stove, should also be added to the pit. Scrape off the dung and the topsoil in the carabao corral and dump it into the pit. When fresh dung is placed in the pit, cover the dung immediately with a layer of soil to prevent flies from laying eggs there. Gather bones and after pulverizing them throw them into the pit. When the pit is heaping full, cover it with soil and wet it thoroughly once a week during the dry season. After five to seven months the vegetable matter will be sufficiently decayed to be used as manure. The rotted manure should then be taken from the pit and worked in with the soil. The pit may be refilled as soon as it is emptied.

Plowing under refuse in the fields. Many Philippine farmers burn weeds, grass, straw, and other similar matter in their fields. This is a great mistake, for often their soils

FIG. 39. The Igorot farmers follow many excellent practices. This girl is burying sweet potato vines to fertilize the soil for a crop of rice.

are much in need of the vegetable matter that they are burning up. In the Hawaiian Islands, the leaves from the sugarcane are carefully piled between the rows and earth thrown over them, so that the leaves will decay in the soil. On a cinchona (quinine) plantation in Java the weeds and other vegetable matter are buried in holes near the cinchona trees. In all countries the use of fire in the fields makes the land poor, and where the land is poor the people also are poor.[1] Every farmer should remember that when he burns a pile of weeds or grass he is destroying the fertility of his fields. It requires large plows drawn by at least two animals to turn under and bury this vegetable material, but plows of this kind should be used.

Liquid manure. Liquid manure is very useful in forcing a quick growth in certain vegetables in the garden. It can be made by putting fresh manure into a large can, jar, or

[1] One writer has said: "Farmers should use less fire and more sense in the care of their lands."

barrel until the can is two thirds full and then filling the can with water. Keep the vessel covered. After three or

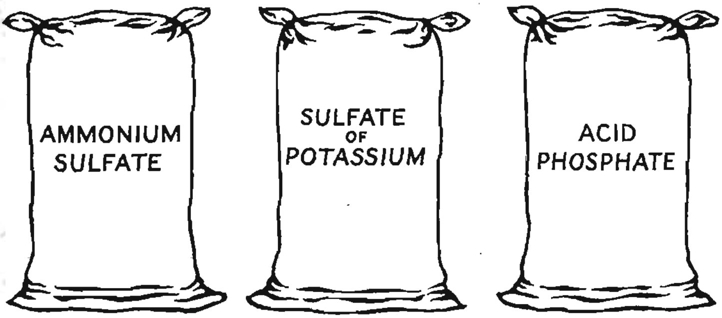


FIG. 40. Three valuable commercial fertilizers.

four days the liquid will be ready for use. The vessel may be filled several times before the manure needs changing. A good liquid manure can also be made by dissolving 1 gram of sulfate of ammonia in 3 liters of water.

Liquid manure and compost pits are used more in connection with flower and vegetable gardens than with field crops.

Commercial fertilizers. Certain materials that are rich in plant foods are called *commercial fertilizers.* They are called " commercial " because they are bought and sold in commerce, and " fertilizers " because they fertilize or enrich the land. In reality there is no clear distinction between a fertilizer and a manure. Fertilizers are only very rich manures that need to be used in small quantities and can, therefore, be profitably shipped from place to place and sold to farmers. Lumbang oilcake and guano are commercial fertilizers that are used quite commonly in the Philippines. They do not add much vegetable matter to the soil, but they are valuable be-

FIG. 41. A cave at Dumalog, in Capiz Province. Tons of bat guano were found in this cave.

cause of the plant foods (nitrogen, phosphorus, and potassium) that they contain. Fertilizers usually give their results quickly, and if a farmer depends on them, he must keep buying them year after year. They cannot be expected to take the place of farm manure and green manure on a farm, but they may sometimes be profitably used to supplement these.

Oilcake. The material that is left after the oil is pressed from the seeds of the peanut, cotton, coconut, lumbang, kapok, and castor-oil plant is called *oilcake.* It is a very valuable fertilizer for use in gardens and also for use in the fields in growing sugarcane and coconuts. In one hundred kilos of oilcake there are about four kilos of nitrogen, the most expensive food material for plants.

Guano. The accumulated dung of bats, sea-birds, or any decomposing animal remains is called *guano.* On certain islands off the coast of Peru and off the east coast of Africa sea-

bird guano is found in beds fifteen to twenty meters thick. In the Philippines, bat guano is found in caves and old buildings. Manure made from fish is called *fish guano.* The word "guano" in the Peruvian language means dung.

FIG. 42. Bones at a fertilizer factory, ready to be ground and made into bone meal.

Bone meal and tankage. Horses, cattle, carabaos, and dogs that die in Manila are taken to the Candle and Manure Factory, where they are steamed in a large iron tank. The fat is converted into stearine for the manufacture of candles or is used to make soap. The large cooked bones are ground separately and sold as *bone meal.* This is especially rich in phosphorus. The cooked intestines, meat, etc., are dried, ground fine, and sold as *tankage.* This is an excellent fertilizer. Before the dead animals are steamed, their skins are removed, to be later made into leather.

Mineral fertilizers. Certain rocks in the United States are rich in phosphorus. These rocks are ground and shipped to all parts of the world for fertilizer. In Germany there are beds of potash in the earth, and most of the potash used in fertilizers comes from these mines. In Chile there are places where there are deposits of mineral salts that contain nitrogen, and great quantities of these salts are mined and used as fertilizers.

These mineral fertilizers contain the same plant foods as are found in decaying vegetable matter, but they do not add vegetable matter to the soil. The farmer, therefore, should

not depend upon fertilizers alone, but should save his animal manure and plow under as much vegetable matter as possible. The kind and amount of fertilizers that can be profitably used will depend on the condition of the soil and the crop to be grown. They are usually placed on the soil at the rate of 1 kilo to every 15 to 45 square meters. More than this may be used in gardens.

Lime. Acids collect in most agricultural lands, with the result that the soil becomes sour. These acids can be destroyed by adding lime to the soil. Lime also makes clay soils more porous so that they are more easily cultivated. On some fields in the Philippines the plants will grow better if lime is added to the soil. In Manila lime costs a little less than 5 centavos a kilo, and 1 kilo may be applied to 5 square meters of land. It should be worked into the soil before a crop is planted and should not be used oftener than once every three years. Wood ashes also will sweeten a sour soil, and they contain a rich supply of potash that is used by the plants. Ashes should not be thrown away, but should be kept dry and later applied to gardens and to fields. If they are exposed to rains, the most valuable substances in them will be lost.

How to tell when a soil needs lime. A good way to tell if a soil is sour is to make a slit with a knife in moist soil and place in the slit a strip of blue litmus paper. Pack the soil about the paper and after ten minutes remove the paper. (For this test blue litmus paper of the best quality is necessary. It can sometimes be obtained from the drug store.) If it has become red, the soil is sour and may need lime to produce the best plant growth. Some plants grow well in acid soils and some do not.

The best way to learn if a soil needs lime is to apply lime to a strip of land across the field. If the crop grows better on this strip, the whole field may then be limed. Lime is applied in the form of finely pulverized limestone, coral rock, or sea shells.

Classification of manures and fertilizers	Animal	Tankage Dried blood Bone meal
	Vegetable	Green manure Oilcake Decaying vegetable matter
	Animal and Vegetable	Farm manure Guano Compost
	Mineral	Potash Phosphates Nitrates Lime

EXERCISES

Exercise 25. To find how much water decaying vegetable matter will hold. Take a bamboo tube and tie a piece of cloth over one end. Weigh the tube and then fill it with dry decaying vegetable matter from a log or hollow tree. Weigh the tube again and then set it in a can of water. The water should come to the top of the tube. After 24 hours lift out the tube, allow it to drain, and then weigh it again. How much water is held by the vegetable matter?

Exercise 26. To show that weathered manure is less valuable than fresh manure. Take two bamboo pots (about 20 centimeters high) that have holes for drainage and fill each with dry pulverized clay. Pour out on a paper the clay of one pot and thoroughly mix

with it one wineglassful of fresh carabao, horse, or other dung and return the mixture to the pot. To the clay in the other pot add one wineglassful of a manure similar in kind to that added in the first pot, except that it has been exposed to the rain and sunshine for a long time. Label each pot; plant 3 kernels of corn in each, add water, and later compare the plant growth in each pot.

NOTE. In all these experiments with manures and fertilizers, the materials should be thoroughly mixed with the soil. The surface of the soil in the pot should not be closer to the top than 3 centimeters.

Exercise 27. To test the effects of manure on the growth of plants. Take 7 large bamboo pots with holes for drainage, enough fine clay to fill the pots, a small quantity of fresh animal manure (horse, cow, carabao, goat, chicken). Pour out on a paper the fine clay from one pot and mix thoroughly with it one wineglassful of horse manure, and return the mixture to the pot. In a similar manner mix the other manures and clay. Let two pots have clay without manure. These are the "check" pots. Label each pot and plant there 3 kernels of corn. Place the pots where they will get sunlight, but not rain and wind. Let the plants grow for four or five weeks and then compare them as to (1) height of plant, (2) size of stem, and (3) color, length, and width of leaf. Remove the plants carefully from the pots and compare (4) the root development. How does manure help plants to grow?

Exercise 28. To test the effects of green manure and of ashes on the growth of plants. Dig up carefully 2 small peanut vines, or 2 other plants of the legume family, and pound them to a pulpy mass. Place one wineglassful of the mass in a frying pan over a fire, heating it until it is burned to ashes. Take 3 pots of clay, add the ashes to one pot, one wineglassful of the green vegetable matter to the second, and use the third as a check. Observe the growth of the plants. Are the ashes as beneficial as the vegetable matter?

NOTE. The teacher should impress on the class the need for vegetable matter in the soil. The farmer who burns the weeds and refuse from his

fields or throws them into the river leaves his plants with only the rock particles of the soil. He is acting as unwisely as a housewife would act if she threw the food out of the window and set her family down to the bare dishes.

Exercise 29. To test the effects of commercial fertilizers and lime on plant growth. Prepare 10 pots as in Exercises 26 and 27. Add fertilizers to the soil as follows, using a small spoonful in each case:

Pot No. 1 Sulfate of ammonia
Pot No. 2 Sulfate of potash
Pot No. 3 Acid phosphate
Pot No. 4 Sulfate of ammonia and sulfate of potash
Pot No. 5 Sulfate of ammonia and acid phosphate
Pot No. 6 Sulfate of potash and acid phosphate
Pot No. 7 Sulfate of ammonia, sulfate of potash, and acid phosphate
Pot No. 8 Lime
Let the ninth and tenth pots be the check pots.

The soil in each pot should not be closer than 3 centimeters to the top. Plant 3 kernels of corn 3 centimeters deep in each pot, and then add an equal amount of water to each. When the plants are large, add water often. Do not allow the leaves to wilt. After 4 to 6 weeks compare the plants. If this exercise can be going on at the same time as 26 and 27, valuable comparisons can be made and a greater number of checks will be available.

NOTE. A similar experiment might be tried in the garden, using plots 1×4 meters and $\frac{1}{2}$ kilo of fertilizer in place of a spoonful. Plant the same crop (as mustard, lettuce, cabbage, pineapple, onion) on each plot and give each plot the same amount of water and tillage. To obtain the best results, fertilizers should be scattered on the soil and thoroughly worked in before seeds are sown or plants set. As a rule, they should not be used during the rainy season, as they may be washed away before the plants can use them.

Exercise 30. To determine the effect of lime on clay. Take a large, clean bottle and fill it with clear water. Add one large spoon-

ful of fine clay, and shake the bottle thoroughly for 3 or 4 minutes. Let the contents settle for 5 minutes. Take 2 glass tumblers or clear-glass bottles, and add an equal amount of water to both from the large bottle, being careful not to stir up the clay sediment. Into one tumbler place a quantity of fine lime, equal in size to a kernel of corn. Stir the water in this tumbler until the lime has disappeared. Set the two tumblers aside and note any difference or change in an hour, or overnight. Which bottle contains the clearer water?

Place clear water in a can and stir in with it a quantity of clay soil. Wait 5 minutes for the coarse particles of soil to settle and then fill 2 tall, clear-glass bottles each half full with the muddy water. Fill up bottle No. 1 with fresh water and bottle No. 2 with ocean water. Shake both bottles thoroughly and set them aside. After 24 hours notice the color of the water in each bottle. What effect has ocean water upon the soil particles suspended in muddy river water? Give two reasons for mud being deposited near the mouths of rivers that empty into the ocean.

Exercise 31. To determine the effect of lime on the texture of baked clay. Take two coconut shells or tumblers and fill them with fine clay. Into one put a small spoonful of fine lime. Add water to each shell, and stir until the clay is puddled like soft mud. Set the shells in the sunshine and where the wind will blow over them. When the clays are somewhat dry, remove them from the shells but keep them in the sunshine and wind. When they are completely dry, break them apart with the hands. What difference is there and what is the reason for it? Which clay could be more easily plowed? How can a clay soil be changed so that it can be plowed more easily? Repeat this exercise, using sand instead of clay.

NOTE. If the soil in your garden is hard and difficult to till, it probably contains a large amount of clay. Such soils may be improved by adding sand, lime, and vegetable matter.

CHAPTER VIII

CONTROLLING THE SUPPLY OF WATER IN THE SOIL

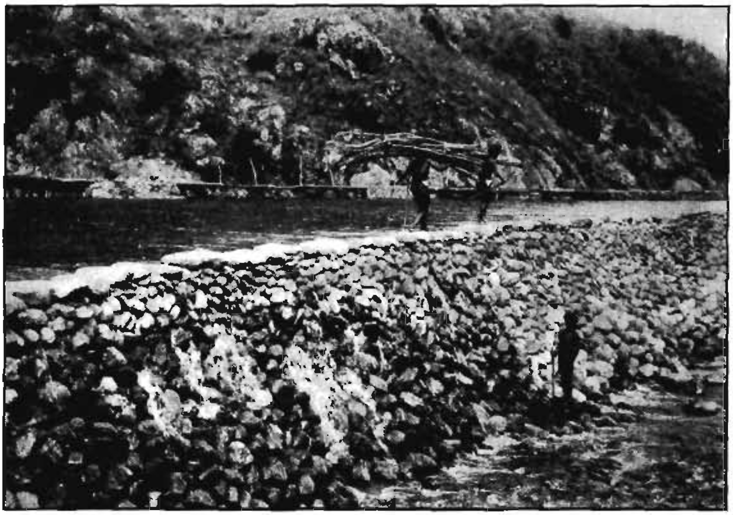


FIG. 43. A dam made by the mountain people for irrigation purposes.

PLANTS grow best when they have just the right amount of water. They need water at all times, and either too much or too little will retard their growth. During the rainy season the soil is filled with water for weeks at a time, and during the dry season the topsoil may be as dry as the soil of a desert. Controlling the supply of water in the soil is, therefore, a question of first importance. Indeed, it is the most important problem in all agriculture.

How the supply of water in the soil is controlled. The amount of water in the soil is controlled by *drainage,* by

irrigation, by *mulches*, and by the *addition of vegetable matter to the soil.* During the rainy season, when the water supply is too abundant, the farmer must remove a part of it by drainage. During the dry season, either he must supply water by irrigating his land, or he must retain in the soil the water that falls during the rainy season for the plants that grow during the dry season. He does this by adding vegetable matter to the soil (page 62) and by keeping the topsoil so loose that a soil mulch is formed.

Drainage. When a soil is soaked with water, the water fills the spaces between the soil particles and drives out the air. This water must be drawn off quickly, or the roots of the crops will be injured because of a lack of air.

Sometimes ditches are dug to allow the surface water to run away. These cost the farmer only his labor. After a rain the farmer should watch where the water runs naturally and dig his ditches in these places. They should be large enough to carry the water away quickly, but not so steep that the soil is washed away. The ditches should be kept clean.

In some countries the water in the soil of certain fields is removed by the use of drain-tiles. A drain-tile is made of moist clay that is shaped like a bamboo tube and then burned or baked like a brick. Narrow ditches are dug and the tiles laid end to end in the bottom of the ditch. The ditch is then filled with soil. Water enters the tiles at the joints. The tiles in each ditch should have a continuous slope to the outlet.

The laying of tile is very expensive and should be carefully done. If tile is improperly laid, the water will not run away. The cost may be ₱250 or more a hektar. The cost of tile drains would be considered very great for farms in the

Philippines, but many farmers in different parts of the world have found it highly profitable to drain their land by tile. Tiles do not interfere with plowing and cultivating the land

FIG. 44. Laying tile for tile drainage. The tiles are round, like bamboo tubes; they are made of clay and baked the same as bricks or rice-pots. Each tile is lowered by a long stick that is hooked at one end.

as do open ditches, and they do not occupy land that might be used for crops. During hard storms, however, open ditches will carry water away quicker than tile.

Irrigation. Sometimes the water that is used in irrigation is lifted from a lower to a higher level by means of a pump that is worked by an engine. From the pump the water is conducted to the fields by ditches. Sometimes a dam is built across a stream so that the water which falls during the rainy season is stored for the use of plants during the dry season. Sometimes a dam is built across a stream so that the water of the stream is turned into a canal or flume that carries it to the fields that are on lower land. The bringing

of water from any source to land upon which it is to be used, and controlling the distribution of this water, is irrigation.

In India, Egypt, the United States, the Philippines, and other parts of the world, vast sums of money have been spent in the construction of dams and canals for irrigation. The water is taken from creeks, rivers, and wells. Water from creeks and rivers carries considerable quantities of plant food that has been taken from the soil. River and creek water is, therefore, somewhat better for irrigation than is well water.

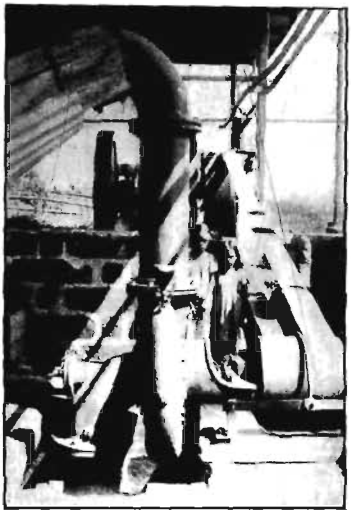


FIG. 45. An 18 horse-power petroleum engine, used to operate a large pump, from which the water runs into a canal that conducts it to the fields.

Systems of irrigation. When rice is irrigated the entire surface of the soil is flooded; the water is held in check by dikes, and the soil becomes saturated, that is, filled with water. This is called the *flood system* of irrigation.

When sugarcane or betel-leaf is irrigated, the water is allowed to run in furrows between the rows and soak into the soil. This is called the *furrow system* of irrigation. Where it is not possible to conduct water in furrows, a good way of applying it to plants such as coconut trees, is to dig a furrow around each tree and fill the furrow with water. Immediately after the water has been absorbed, fill the furrow with dry soil and cover it with vegetable matter 10 centimeters thick.

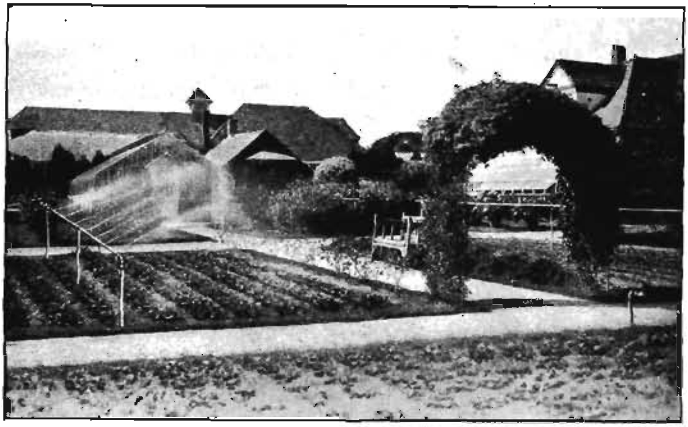


FIG. 46. The overhead system of irrigation.

In vegetable and flower gardens, water is sometimes carried in buckets and poured on the soil near the plants. This is called the *bucket system* of irrigation. The best vegetable gardeners in the Philippines use the bucket system. Where water under pressure can be had cheap, gardeners sometimes arrange overhead pipes that have small holes every 45 centimeters, through which pass small streams of water. The pipes are so arranged that the water is evenly distributed. This is called the *overhead system* of irrigation.

San Miguel irrigation system. The Philippine government has recently completed at San Miguel, in Tarlac Province, a modern irrigation plant, which will supply water to irrigate 5000 hektars of land. The system includes a great concrete dam which turns the water from the river into the main canal. This canal is 16.5 kilometers long. Smaller canals take the water from the main canal and distribute it to the ditches

that carry the water to the rice plots. The arrangement of the canals and the rice plots is like that of a tree: the main canal corresponds to the tree trunk, the smaller canals to the branches, the small ditches to the petioles of the leaves, and the rice plots themselves to the blades of the leaves. Along the main canal is a small waterfall, or "drop," as it is called. Its purpose is to lessen the grade of the canal so that the water will not flow so rapidly. In this way the washing away of the canal banks is prevented. (See Frontispiece.)

The water-holding capacity of soils. A sandy loam soil will hold on the surface of its particles about one fifth of its own volume of water. That is, in a sandy loam soil that has been saturated and then drained so as to remove the water between the particles, there remains on the soil particles one fifth as much water as there is soil. This means that in the top half-meter of a field of moist sandy loam, there is enough water clinging to the soil particles to make a layer ten centimeters deep over the entire field. A moist clay loam will hold one third of its own volume of water on its soil particles, and a soil rich in vegetable matter (like that found in swamps) may hold half its own volume.

If all the water in the top meter of soil were spread on the surface of the land, how deep a layer of water would there be over fields having soils like those described above?

Increasing the water-holding capacity of soils. The more vegetable matter there is in soil the more water the soil will hold. The farmer who adds vegetable matter to his soil, therefore, makes the soil able to store water and hold it for the use of his crops when there is no rain. Notice how a corn crop that is growing in well-manured soil keeps green during the dry months. It is because the vegetable matter

FIG. 47. On the left the soil was tilled deep; on the right, only to the usual depth. Note the difference in the crop.

in the soil is furnishing the plants with the water that they need.

The advantage of having the roots of crops grow deep into the soil. In a moist clay loam, how much water would the roots of a corn crop find in the top twenty centimeters of soil? How much water would the roots find if they could grow a meter deep in the soil? Answer these questions, and you will understand the advantage that a deep-rooted crop has. The deeper the roots go into the soil the more water will they find for the plants. It is important, therefore, for the farmer to know how to make the roots of his crops grow deep into the soil.

Getting the roots to grow deep into the soil. Roots will grow deep into soil that is loose and that contains sufficient air and water. *One of the most important points in all agriculture is deep tillage;* for this breaks up the hard layer beneath the topsoil and allows the air and the roots to go down deep

into the subsoil.[1] The Philippine farmer should use a larger plow, have several strong animals to pull it, instead of one animal, and should break up his land much deeper than is

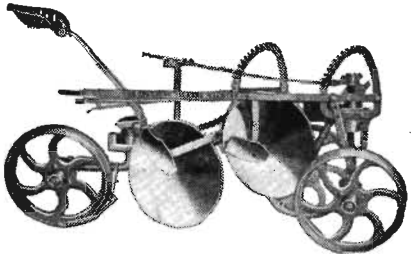


FIG. 48. With a plow of this kind the soil can be broken up 40 centimeters deep. It requires about 8 bullocks to pull it.

now the custom. Adding vegetable matter to the soil makes it more porous and also makes it possible for the roots to grow deeper into the soil. It also makes the soil easier to plow.

Drainage also is important in getting the roots of plants to grow deep into the soil. The farmer who drains his land leads the free water away from among the soil particles and allows the air to enter the soil. This permits the roots of his crops to grow deeper into the soil, and the draining of the land helps the crops in dry weather as well as in wet weather. One great advantage of tile drainage is that it draws air deep into the soil and allows the roots of the crops to go so deep that they often find an abundant water supply even during a dry season.

Using mulches to prevent the escape of water. Toward the end of the rainy season there is a large quantity of water

[1] On the sugar plantations in the Hawaiian Islands the plows are drawn by engines and the land is plowed almost a half-meter deep.

FIG. 49. Cowpea plants placed around banana trees for a mulch.

in the soil. Later, if the topsoil becomes dry and cracks, the water from below rapidly comes up to the surface and evaporates into the air. But if the soil is covered with a mulch, evaporation from the surface is checked and the soil water does not escape. Grass, leaves, or other vegetable matter make an excellent mulch, or a loose layer of dry soil may be used. Vegetable matter, when mixed with a soil, makes the soil loose. It prevents the soil from baking and thus prevents the water in it from escaping.

The importance of cultivating crops during dry weather. During a severe drought all the corn in a certain region suffered greatly except the crop of one farmer. His corn plants remained dark green while all his neighbors' plants wilted and turned brown. He kept his plants green by cultivating the soil between the rows every few days throughout the growing season and harvested a fair crop while his neighbors had almost none.

How does cultivation help a growing crop? It does so by

keeping the water in the soil. The loose layer of dry soil on the surface prevents the evaporation of the soil water, just as a layer of grass or leaves prevents the evaporation of this

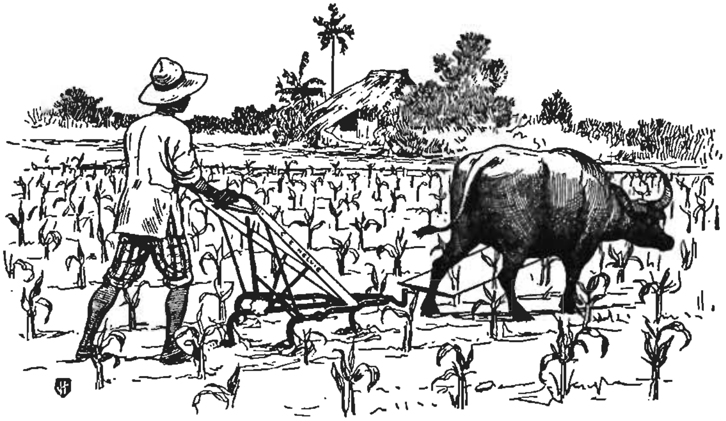


FIG. 50. Keeping the surface of the soil loose and all weeds killed prevents the escape of water during the dry months.

water. The farmer, therefore, should not allow the surface of the soil on his fields to bake and crack, but should cultivate the land and keep the surface of the soil loose. He should be especially careful during the dry season to stir the soil promptly after a rain; for if the soil of his fields is allowed to lie with a crust on it, the water in the soil will quickly evaporate into the air and his crops will be left without the moisture that they need for their growth.[1] If the cultivator breaks the roots of plants like corn, the plants will

[1] In some parts of the world where there is rain during only three or four months of the year, farmers practice "dry farming." They loosen the surface of the soil as soon as the rains are over and raise their crops during the dry season with the water that is in the soil. The topsoil is tilled often. In the parts

suffer. To make a mulch the surface of the soil should be tilled frequently.

Weeds use the water needed by crop plants. Weeds, like other plants, take water from the soil. Cultivated fields and gardens, therefore, should be kept free from weeds, because the weeds use water needed for the crop plants.

The limiting factor in plant growth. Suppose a farmer has a field of sugarcane, and there is phosphorus enough in the soil to give a crop that will yield four tons to a hektar. Suppose there is nitrogen enough to yield one ton, and potassium enough to yield five tons. Suppose, also, that the farmer is able to irrigate his field so that his crop has all the water that it needs. What will the yield be? It will be only one ton. There is not enough nitrogen for more than this amount, and the yield cannot go beyond this point. The abundance of other food materials and of water is of no use, because without the nitrogen the crop cannot take advantage of them. The nitrogen *limits* the crop.

A chain is no stronger than its weakest link. A cart carries no heavier load than its weakest part will support. A tub cannot be filled with water higher than its shortest stave. If anything that a crop needs is lacking, the lack will prevent the farmer from getting a good crop. There is always some one thing that prevents a crop from being larger. This, whatever it may be, is called the "limiting factor" in the growth of the plants. It is important to understand this point, for the farmer should supply first the thing that his crop needs most.

of the Philippines where there is a pronounced dry season, the farmer should follow this same method. Toward the end of the rainy season the topsoil should be tilled often, or a vegetable mulch should be placed on the soil.

A hungry man needs food and not water. A thirsty man needs water more than he needs food.

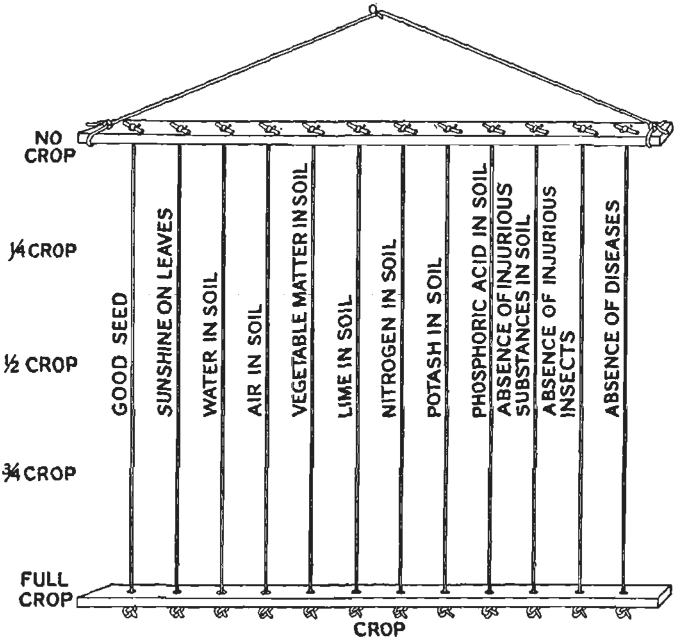


FIG. 51. A device to illustrate limiting factors in crop production. If any cord is shortened the stick representing the crop must rise. (Exercise 41.)

Water as a limiting factor. A certain sugar planter, when his fields were very dry and his crop was in great need of water, spent several thousand pesos for commercial fertilizers and applied the fertilizers to his land. This money was not well spent; for the plants needed water worse than they needed food materials. The farmer had two brooks on his farm and he should have used his money to buy pumps for lifting the water so that it could be run on the soil near the sugarcane

plants. In many other cases it is water that plants need most of all; very commonly water is the limiting factor in the growth of the farmer's crops.

Before investing money in commercial fertilizers a farmer should be fairly certain that the limiting factor of plant growth on his farm is not shallow plowing, a lack of vegetable matter in the soil, or lack of water control. On each field and for each crop the limiting factor should be found out and supplied. The farmer who does this intelligently will be the one who makes the most money.

EXERCISES

Exercise 32. To show the necessity for drainage. *A.* Take two large bottles and remove the bottom of each. This can be done by winding a soft string around the bottle. Saturate the string with kerosene and set fire to it. As soon as the string burns up, put the bottles in cold water. This will cause the bottle to crack where it was heated by the string. The sharp edges of the glass can be rounded off with a file. Fill the neck of each bottle with coconut fiber or grass roots and then fill the bottles with coarse sand, within 5 centimeters of the top. Plant 3 kernels of corn in each bottle. Add water when needed. As soon as the corn has come up, place a cork in one bottle and leave the other bottle open. Put the same amount of water in each bottle daily. Observe results carefully and at the end of 4 weeks remove the plants and compare them as to height of stalk, color of leaves, and root development. Why should agricultural land be drained during the rainy season?

B. Take 2 large bamboo pots, each 1 meter high. Have the bottoms solid, but in one pot make a hole for drainage in the side 50 centimeters from the bottom. Fill the pots with soil, plant in each 3 grains of corn, and let them grow for several weeks, watering as needed. Then split the pots and note the growth of the roots. Explain what you find.

Exercise 33. To determine the water-holding capacity of different soils. Secure gravel, sand, clay, and decaying vegetable matter like thoroughly rotted compost or wood from some hollow tree. Dry thoroughly; fill a pot with each kind of soil and weigh it. Set all the pots in a can of water for 24 hours. Remove from the water and drain until no more water comes from any of them. Weigh them again. Which has gained most in weight? Do the finer or coarser soils hold more water? How does the vegetable matter hold water? How does animal manure or green manure increase the water-holding capacity of a soil?

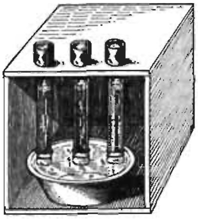


FIG. 52. Exercise 34, to show that water is drawn upward.

Dip a stone into water. Where is the water held? Crush the stone into fine pieces. Does this increase or decrease the surface of the stone? Will the many pieces hold more water than the stone held before it was broken?

Exercise 34. To show the rise of water in soils by capillarity. Take 3 lamp chimneys and tie a cloth over the bottom of each. Fill one with fine gravel, another with dry sand, and the third with finely pulverized dry clay. Put the chimneys in a rack which will permit the lower part of the chimneys to rest in a basin full of water. The ends of the chimneys should extend about 1 centimeter below the water. Observe the rise of water in the different soils. Make note of the time it takes the water to rise to certain heights in the different soils. In which does it rise most rapidly? Does it rise most rapidly at first or when the water is near the top?

NOTE. Water rises more slowly through fine soils than through coarse soils, but after the first 35 or 40 centimeters it rises so *very slowly* that capillarity in any soil may be neglected. Unless there is free water or a stream of underground water close to the surface, there will not be enough water brought to plants by capillary action to be of much value to them. The roots must grow to the water and not wait for the water to come to them.

Exercise 35. To determine the effect of deep tillage on the growth of plants. Stake out 5 plots of equal area and give to each plot a number.

In plot No. 1 till the soil 10 centimeters deep.
In plot No. 2 till the soil 20 centimeters deep.
In plot No. 3 till the soil 30 centimeters deep.
In plot No. 4 till the soil 40 centimeters deep.
In plot No. 5 till the soil 50 centimeters deep.

Then transplant to each plot the same number of plants. Give each plot the same amount of water and cultivation and at harvest time compare the results.

NOTE. In case the soil has received only shallow cultivation previously, the subsoil must not be brought to the surface. Loosen it, but leave the topsoil above it.

Exercise 36. To illustrate the action of a soil mulch. *A.* Take a cube of loaf sugar. On the top side sprinkle a quantity of powdered sugar. The cube of sugar represents the soil and the powdered sugar a soil mulch which is produced by making fine the surface soil. Set a tumbler bottom side up on a table and put a small quantity of coffee or water colored with ink on the top of the tumbler. Carefully set the cube of sugar in the liquid. Notice how quickly the liquid rises to the top of the cube and then stops. The powdered sugar "mulch" does not take up the liquid as the solid lump of sugar did. In time, however, the mulch becomes moist. The water passes up through the cube of sugar until it reaches the surface. It passes slowly into the powdered sugar because there are air spaces between the particles of powdered sugar and between the powdered sugar and the cube.

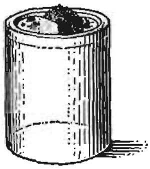


FIG. 53. Exercise 36 *A*, to illustrate how a mulch prevents water from rising to the surface.

NOTE. A loose layer of soil on a field, like the powdered sugar, prevents the water from rising to the surface. When the soil is packed, the water climbs up through it, passing from particle to particle, until it reaches the surface and passes off into the air. The loose soil contains air spaces that check the rise of the water, — the water cannot get across these air spaces to the soil above. The water, therefore, does not reach the surface and is kept in the soil. When rain falls on a mulch, the soil is beaten down and packed. Then the water will pass through it to the surface and be evaporated. If water in the soil is to be retained, the surface should be loosened with a harrow, disk, or cultivator after each rain.

B. Take 2 lampwicks, each about 20 centimeters long; cut one in two and wash the three wicks with soap and water. When they are dry, fasten the two short wicks together with pins. Suspend the wicks, as shown in Figure 54, so that the lower ends are in water that contains coloring matter. After a few hours the water rises in both wicks. The part of the wick above the cut represents a mulch. Water cannot readily pass over the cut surface, as the contact between the fibers is broken at that place. In a similar manner dry loose soil on the surface prevents the rise of water to the surface. Dead leaves and grass on the surface of the soil prevent the escape of moisture in the same way.

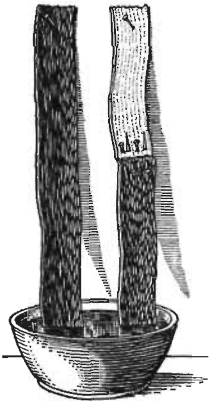


FIG. 54. Exercise 36 *B*, to illustrate how a mulch prevents water from rising to the surface.

Exercise 37. To show that a soil mulch prevents the evaporation of water. Fill two pots that are without holes for drainage with wet clay, packing the clay thoroughly and smoothing off the surface. Allow them to stand until the clay is dry enough to crumble when worked. Loosen thoroughly the top 6 centimeters of one pot, thus forming a soil mulch on it, and then weigh each pot. Set the pots aside

for a week or more and weigh them again. Which has lost the more water? This experiment will work best during the dry season.

NOTE. At the end of the wet season in the Philippines there is always an abundant supply of water in the soil. By keeping a soil mulch on his fields during the dry season the farmer can keep the water in the soil for his crops. If a crust is formed on the surface by a rain, the soil should immediately be cultivated again.

Exercise 38. To prove that a vegetable mulch prevents the evaporation of water from the soil. Prepare 3 pots as in the previous experiment. Weigh them. Cover the surface of one with a layer of decayed vegetable matter 3 to 5 centimeters thick. Cover the second pot with a similar layer of straw, and use the third as a check. The pots should be level full. Reweigh after a week. What are the results?

Exercise 39. To show the effects of soil mulch on plant growth. During the dry season prepare in the usual way two garden plots having the same kind of soil and transplant to the plots lettuce, pechay, or mustard plants. Water the plants thoroughly until they are well started, but after that do not add more water. Cultivate the soil of one plot 6 centimeters deep every 3 or 4 days. Allow the other to go without cultivation. Keep both plots clear of weeds. On which plot are the plants more productive?

NOTE. The old way of growing coffee and cacao was to keep the trees shaded. It is true that the large trees shaded the soil and the green leaves of the growing crop, but they took from the soil large quantities of water and other plant foods that should have been left for the coffee and cacao. The new way is to grow these crops without shade. It has been found that both coffee and cacao trees keep healthier and bear more fruits when allowed to grow in the sunshine, and that water and plant food in the soil can be controlled by mulches. Cacao grows best when leaves and grass are scattered on the soil, and corn, tobacco, and sugarcane when the topsoil is kept thoroughly tilled.

Exercise 40. Repeat Exercise 39, using a manure or straw mulch on one of the plots.

Exercise 41. To illustrate the limiting factor in plant growth. Secure 2 sticks each 30 centimeters long. In each make 12 holes 2 centimeters apart, as shown in Figure 51. Take 12 small lead or stone weights and 12 strings, each about 80 centimeters long. Tie a weight to the end of a string, pass the other end through a hole in each stick, and tie the free end to a small stick. Arrange all the weights and strings in a similar manner and hang the device on the wall over a strip of white paper. Label string No. 1 " Good seed," string No. 2 " Sunshine on the leaves," and the other strings " Water in the soil," " Air in the soil," etc. Label the stick at the bottom " Crop," and at each end tie an ear of corn, a tobacco leaf, or some other product. Each string represents one of the requisites for plant growth. When the strings are at full length, all the conditions for luxuriant plant growth and a full crop are represented. By pulling up one or more of the strings, thus lifting the " crop," it can be shown that if one or more of the requirements are lacking, a full crop will not be harvested. With respect to the farm plants growing in your neighborhood, what is lacking to secure a full crop?

NOTE. The teacher should make sure that the class understands the principle of the limiting factor in agriculture and its applications to the production of crops. An additional illustration may be provided by drawing on the blackboard a chain of ten links of varying size. The weakest link in the chain will represent the limiting factor. If this weak link is replaced by a strong link, the chain will then be stronger and possibly some other link will be the limiting factor. It would be very foolish to leave the weak link in the chain and replace some strong link by another strong link. The farmer who finds the limiting factor (the weakest link) and by controlling conditions removes it (by replacing the weak link with a strong link) will gain wealth (have a strong chain).

CHAPTER IX

FARM CROPS

FIG. 55. Weeding rice by hand in a California rice field.

THERE are certain animals like the horse, cow, hog, dog, and cat that civilized man takes with him wherever he goes. These are called *domestic animals.* They are useful to man; he has trained them and makes them serve him; and without the help of these animal friends his life would be much more difficult.

There are certain plants that may be called *domestic plants.* The farmer cares for them just as he cares for his animals. He takes care of their young; he protects them from the injurious plants (weeds); and he provides a supply of water and of food materials for them. What domestic animals a man shall keep depends on the climate in which he lives and on the kind of farming that he does. The plants that a farmer cultivates also differ according to climate and soil, but in gen-

eral they can be divided into *money crops*, *food crops*, and *manure crops*.

Money crops. Crops that the farmer raises to sell, like abacá, tobacco, copra, and sugar, are money crops. When they are sold, the plant food taken from the soil to produce them is removed from the farm. They rob the soil, and the farmer who grows them must find some way to return to his land as much food material as they remove.

Food crops. Crops raised to furnish food for either the persons or the animals living on a farm are food crops. Rice, corn, cassava, grass, sweet potatoes, and gabi are food crops. The manure from the animals fed on the farm, together with all waste parts of plants, should be returned to the soil. If this is done, these food crops will cause practically no loss of plant food from the soil; for an animal keeps in its body only as much of the plants that it eats as it gains in weight. If the animals are fed partly with food grown away from the farm, and the manure is properly handled, the soil on the farm may even gain in plant food. A food crop that is sold becomes a money crop, and when it leaves the farm it carries away part of the fertility of the soil.

Manure crops. Manure crops are grown to be plowed under and enrich the soil. Cowpeas, mungo, peanuts, beans, or other legumes are excellent manure crops, because they are rich in nitrogen. If the seed from these plants is harvested and the leaves and stems of the plants are plowed under and allowed to decay, the soil will be greatly enriched for the growing of later crops. The farmer who plows under a manure crop makes an investment with his land. He gives vegetable matter to the soil in order that the soil may give larger crops to him.

FIG. 56. Plowing under legumes on a Louisiana farm to enrich the soil for rice.

Important Philippine crops. The important crops of the Philippines are rice, coconuts, abacá, sugar, corn, and tobacco. Four of these six crops are food crops as well as money crops. The Bureau of Agriculture, Philippine Islands, estimated that during the year 1913 the value to the Philippine farmers of these crops was as shown in the table on the next page.

Philippine agricultural exports. The farmer should raise on his own farm the food that is used by his family and his animals. Then he should raise a market crop that will give him money for purchasing the things that he needs. An agricultural country should be much like a farmer in the crops that it raises. It should first of all feed itself, and then it should have export crops for which it can secure the money that is needed in the country. Abacá, copra, sugar, and tobacco are the principal export crops of the Philippines.

Crop	Area Cultivated Hektars	Products	Amount Produced	Approximate Average Value per Unit in Provincial Markets	Value of Coconut and Sugarcane Products in Provincial Markets	Approximate Total Value in Provincial Markets
Rice	1,141,242	Cleaned rice	685,968,024 kilos	₱ 0.09		₱ 61,737,122.16
Abacá	368,211	Abacá (Manila hemp)	140,520,332 kilos	₱ 0.23		32,319,676.36
Coconuts (average of 200 trees per hektar)	223,212	Ripe nuts as food	147,981,014 nuts	₱ 0.04	₱ 5,919,240.56	
		Copra	116,699,818 kilos	0.18	21,005,967.24	
		Coconut oil	5,010,540 liters	0.30	1,503,162.00	
		Tuba (a beverage)	42,145,874 liters	0.05	2,107,293.70	
		Total value of coconut products				30,535,663.50
Sugarcane	176,118	Crude sugar	291,386,825 kilos	₱ 0.08	₱ 23,310,946.00	
		Panochas (small cakes)	21,664,663 kilos	0.08	1,733,173.04	
		Basi (a beverage)	8,987,646 liters	0.06	539,258.76	
		Molasses	2,301,452 liters	0.05	115,072.60	
		Total value of all sugarcane products				25,698,450.40
Corn	383,709	Shelled corn	325,450,460 liters	₱ 0.0468		15,231,081.53
Tobacco	68,991	Leaf tobacco	46,060,390 kilos	₱ 0.27		12,436,305.30
Maguey	9,283	Maguey (cantala)	3,619,976 kilos	0.13		470,596.88
Cacao	1,042	Cacao	133,386 kilos	0.90		120,047.40
Coffee	648	Coffee	113,031 kilos	0.80		90,424.80
Total	2,372,456					₱ 178,639,368.33

Equivalents:
1 hektar equals 2.471 acres (English).
1 kilo equals 2.20462 English pounds or 2.174 Spanish pounds.
1 liter equals 0.908077 dry quarts or 1.0567 liquid quarts.

Philippine agricultural imports. An agricultural country should be able to use the money received for its export crops in buying the things that it cannot produce for itself. For example, the Philippine Islands do not manufacture sugar mills, locomotives, and many other kinds of machinery; they do not raise much cotton; they have very few petroleum wells. *The money that they get for their export crops* they must use to pay for machinery, cotton goods, and petroleum.

One difficulty in the Philippines is that part of the money is being used to purchase food that should be raised at home. In 1913 nearly ₱16,000,000 was spent for imported rice, ₱2,000,000 for imported fresh and canned vegetables, and almost ₱1,500,000 for imported meat. As far as possible, these and other food products should be raised in the Islands and the money that is now spent for them saved for other purposes.

EXERCISES

Exercise 42. To make a chart of the principal crops of the district. Make a list of the principal agricultural products of the region. Classify them as money crops, food crops, and manure crops. Include animals that are raised in the district. Place this information on a chart and hang it in the schoolroom. Discuss with the class why these crops are grown and whether there are others that might be equally profitable or more profitable.

CHAPTER X

RICE

FIG. 57. Harvesting rice by hand.

RICE is the principal food of half the entire population of the earth. It is grown in India, China, Brazil, Japan, Java, the Philippine Islands, the southern part of the United States, and in all tropical and subtropical countries that have abundant water. Records show that rice was raised in China over 4700 years ago, and when Magellan first landed in the Philippines he found that rice was the principal crop. It is the most important Philippine crop, and on it the Filipino people depend in a great measure for their food.

The rice plant. The rice plant (*Oryza sativa*) belongs to the grass family. It has long, narrow leaves, with flowers growing along the top of the stem. Each flower has two strong coverings. In the bud these coverings protect the six stamens and the one pistil, and later they form the hulls about the grain. Corn, sugarcane, millet, and bamboo are members of the grass family, and wheat, oats, barley, and rye also are

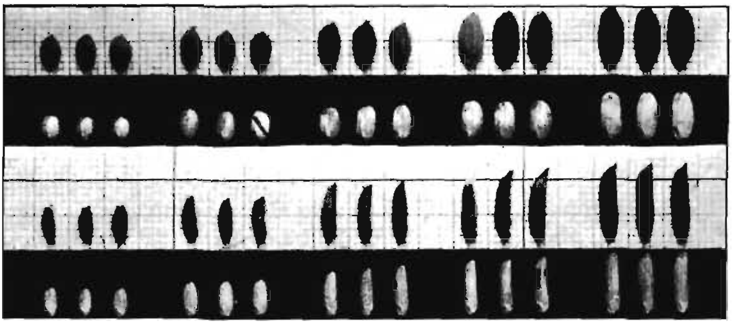


FIG. 58. Ten varieties of rice, showing different-shaped grains. Hulled grains are in the black strips, unhulled grains in the white strips.

members of this family. It will thus be seen that in both the tropics and in the colder parts of the earth, this family of plants furnishes the main food supply of man.

Varieties of rice. There is an immense number of varieties (perhaps a thousand) of cultivated rice. Some of them are

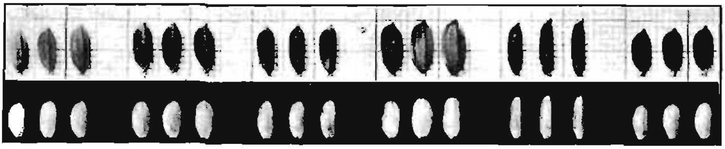


FIG. 59. Grains of six other varieties of rice that differ in color.

best suited to the highlands and some to the lowlands; some are bearded and others are beardless; the grains of some varieties are hard and pearly, and the grains of other varieties are white and starchy; and the different varieties differ in the shape, color, and aroma of the grain. The growing period varies from 120 to 210 days. It is very important for a farmer to select a heavy yielding variety of rice and one that

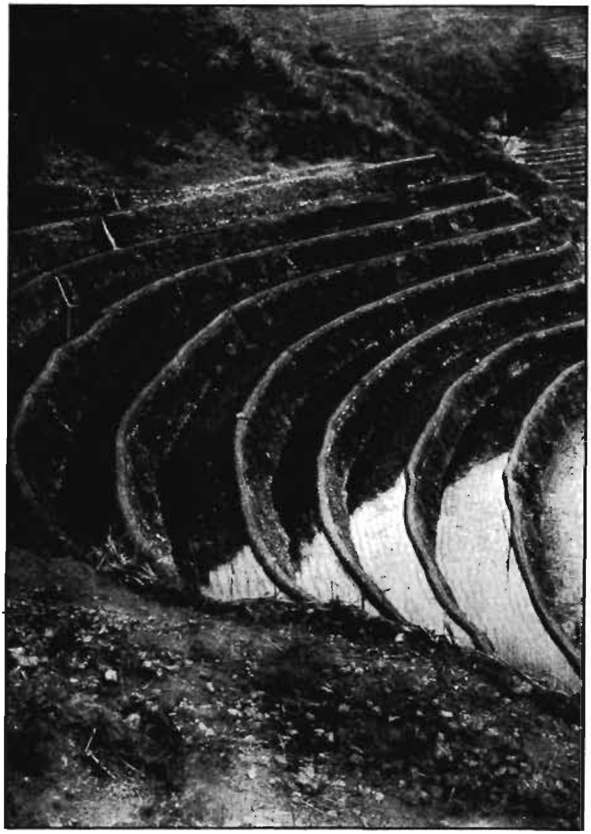


FIG. 60. Steep hillsides terraced and planted to lowland rice.

is suited to his land. Its value on the market should also be considered.[1]

Lowland rice. Lowland rice is a marsh plant and grows best in a saturated soil. During the period of growth, the

[1] See also Book III, Chap. XVIII, concerning value of seed in planting rice. Note especially Figure 102.

field should be covered with water. On hilly and sloping land it is usually planted in irregularly shaped plots inclosed by dikes. These plots should be as long as possible. They

FIG. 61. A rice field.

can then be plowed more quickly, and little land need be occupied by cross-walls. The soil in each plot should be as nearly level as possible. This allows an equal depth of water in all parts of the plot, and the crop will grow uniformly and all ripen at the same time. Good land for lowland rice should have a layer of hardpan (firm soil) below the soft mud to prevent the water from sinking into the ground.

The use of manure in rice growing. One of the most practical methods of adding manure to a rice field is to grow a crop of mungo or cowpeas in a crop rotation. The stems and leaves should be plowed under. Compost, decayed rice straw, and other farm manures may be spread on the land before it is plowed. If too much manure is added, the rice plants will produce long stems, large leaves, and only a few grains. The proper kind and amount of manure to add can be learned by experiments.

FIG. 62. Harvesting rice in California with a binder that cuts about one hektar in two hours. The machine cuts the rice, makes it into bundles, which it ties with twine and then drops on the opposite side.

Raising the seedlings. In the Philippines, lowland rice plants are raised in seed beds and later transplanted to the fields. These seed beds should be on rich soil where the water supply can be controlled. The seed may be planted either in soil that is only moist or in puddled soil (soil that is saturated and worked into soft mud). When the seed bed is puddled, the mud should be so thin that no footprint is left in it when the foot is withdrawn.

Transplanting rice. The young plants should be transplanted when about six weeks old. They should be set the proper distance apart. If they are placed too far apart, valuable land will be wasted; if too close, the plants will not have sufficient food and light and will not mature their grains. Plants that die after being transplanted should be replaced by new plants from the seed bed. Each plot should contain the full number of plants and each plant should yield the greatest possible number of grains. Some varieties of rice require more space than others.

The water supply. To produce a large crop of rice, the plants must have abundant water during the growing season.

FIG. 63. A field of harvested rice in California, showing how the bundles are shocked to dry.

In all parts of the Philippines, owing to the irregularity of the rainfall, the rice crop is uncertain. Rarely is more than one crop harvested in a year. In unfavorable seasons even this one crop is more or less of a failure. In many sections there is abundant water to raise two or three crops each year if this water can be controlled. Wherever it is possible, rice land should be irrigated.

Harvesting. Most rice in the Philippines is harvested by hand. With various shaped knives, the heads of rice are cut either singly or several at a time. The heads are then tied in small bundles. These bundles are sometimes stored. In some sections they are stacked and, after they have gone through a curing process, are threshed.

In some countries rice is harvested by a machine that cuts the grain and ties it into bundles (abacá or maguey twine is used to tie the bundles). One man with three horses and a harvester can cut and bind about five hektars of rice in a day.

Fig. 64. Threshing rice by hand.

Threshing. Rice is threshed in many ways. Sometimes the threshing is done by pounding the heads with a mallet or pestle; sometimes animals are used to tread out the grain; sometimes people rub out the grain with their feet. In some countries threshing machines, run by engines, are used to separate the grain from the straw. Such machines thresh out about 1000 cavans daily and usually do the work for many farmers in a neighborhood. These heavy machines cannot be moved from farm to farm unless the roads are good.

Hulling. In the Philippines, rice when threshed is called *palay*. It is covered with a hull which must be removed before the rice can be used as a human food. This hull may be removed by putting the rice in a trough or mortar and pounding it with a mallet or pestle.

In some neighborhoods palay is hulled in a mill where a series of pestles is operated by water power. In other districts modern rice-hulling machines are run by either gasoline or steam engines. With these machines large quantities of palay can be hulled in a day.

Marketing. Rice is usually marketed from the farm as unthreshed rice in bundles, or as palay. At harvest time it is usually cheap, but after a few months the price goes up. By having a little money laid aside, a farmer raising rice as a money

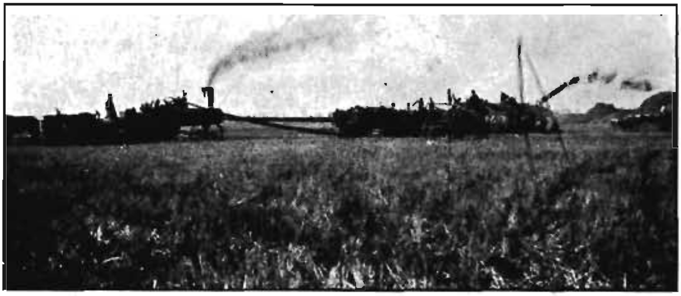


FIG. 65. Threshing rice in California. The dried bundles are carried on wagons to the machine called the separator, which separates the grain from the straw. Notice the straw being blown away and the wagon load of filled sacks. About 50 cavans of palay can be threshed out in one hour.

crop will be able to keep his rice until the highest price can be secured. This is an easy way for a farmer to make money.

Upland rice. Some varieties of upland rice have white grains, while in others the grains are red or black. Varieties that have white, translucent grains about twice as long as they are wide bring the best price. Upland rice usually yields less than 2000 kilos per hektar, but with better tillage and seed selection the yield could be greatly increased. One great advantage in raising upland rice is that it requires much less labor than lowland rice.

Soil suited to upland rice. Almost any moist soil that contains sufficient decaying vegetable matter will produce a good crop of upland rice. If the ground slopes so that the topsoil washes away, terrace the field. To secure the best yield, the soil should be well prepared before the seed is planted. The seed is planted directly in the fields in hills, in drills, or broadcasted on the land.

FIG. 66. Corn and highland rice are sometimes planted with drills. A machine like this makes the furrow, drops the seeds, and then covers them with soil.

Planting in hills. In some places in hilly regions the forest growth is cut down and burned and, at the beginning of the rains, the rice is planted in holes about 20 centimeters apart. A long sharp stick is the only tool used. From 4 to 7 grains are planted in each hole. It probably would have required more work to allow the forest growth to decay on the land than to burn it, as is the custom, but it would have added valuable vegetable matter to the soil. This need of more vegetable matter in the soil is now being realized by progressive farmers in many parts of the world. Rice is often planted in hills between young coconut trees, abacá, or other permanent crops.

Broadcasting. In large fields upland rice is sometimes broadcasted; that is, the seeds are scattered on the soil with the hand, after which the soil is harrowed to cover the seed. The seed bed must be well tilled, if rice is sown broadcast. From 1 to $1\frac{1}{2}$ cavans of seed is used on one hektar. The richer the soil the less seed is used, because in rich soil each plant stools (sends up shoots) more than in poor soil.

Planting in drills. Rice is also planted with a drill. This method insures even distribution of seed and a uniform depth

FIG. 67. Planting rice with a seed drill, on a Louisiana rice plantation.

of planting. Sometimes the seeds are placed in furrows by hand; shallow furrows are marked off and the seeds are planted in these and covered with a harrow.

Thinning. When the rice planted in drills or in furrows is about six weeks old, pull out the weeds that grow between the plants. If the plants are too thick in the row, remove some of them. One plant every 10 centimeters is enough in good soil. Either too many or too few plants in a row will decrease the yield.

Profits on rice growing. A farmer should grow enough rice to feed his family, and if his farm is well located for rice it will be a profitable money crop. There is a good market for it, as rice is still imported into the Philippines in large quantities.

EXERCISES

Exercise 43. To select a heavy yielding strain of rice. Transplant rice seedlings to a small plot, setting them 25 centimeters apart. Use only strong plants and *set only one plant in a place.* At harvest time select 10 or 20 of the best yielding plants, gather the heads from these separately and tie them in bunches. Give the

bunch of heads from each plant a number. Plant the seeds from each plant separately in a seed bed. At the proper time transplant to the plot in the ordinary manner, but set the plants in rows. Have one or two rows from each of the plants from which seed was saved. The longer the rows the better. Harvest the crop and plant the seed from two or three of the best rows. After the best strain or variety has been found, this may be multiplied and used for planting the fields. In case there are different kinds of soils on the farm, the selected variety should be tested in different fields before it is used for planting the entire crop.

NOTE. The farmer wants rice plants that will give a heavy yield when surrounded by other plants. He should therefore select his first plants from the center of the plot, not from near the edge. In this experiment he should set some rows of ordinary rice around the outer edge of the plot and use the center of the plot for the experiment. If any farmer in the neighborhood has already been selecting good varieties, obtain seed from him to start the experiments or to plant an entire plot.

Exercise 44. To show the advantage of rotating crops on rice land. *A.* Select two small rice plots. Plant one in rice year after year. Plant the other in rice, then with a legume (peanuts, cowpeas, mungo), then in corn, and again in rice. Which plot gives the greater yield of rice?

B. On neighboring farms find fields on which rice has been grown year after year and fields on which the crops have been rotated. Compare the yields on these fields. Ordinarily that rotation is good which maintains or increases the vegetable matter in the soil.

NOTE. This experiment is applicable to light, sandy soils rather than to fertile river valleys.

Exercise 45. To show the advantage of adding manure or vegetable matter to rice land. Select 3 small plots on which rice is to be grown for two or more successive years. On one plot allow

the land to lie idle after the rice is harvested. On the second, plant a legume (cowpeas, peanuts, or mungo) after the rice is harvested and work the leaves and stems into the soil before planting the next rice crop; manure the third plot before planting each crop of rice. What effect have the legume and manure on the yield?

NOTE. This experiment is not practicable in all sections of the Philippines.

Exercise 46. To determine the best age for transplanting rice seedlings. Plant the seed as usual in a seed bed. Prepare the soil of a plot, and when the seedlings are 3 weeks old, set seedlings in the usual way, in one quarter of the plot. Two weeks later plant with seedlings another quarter of the plot. Continue transplanting the seedlings until the four divisions of the plot are filled with seedlings 4, 6, 8, and 10 weeks old. At harvest time gather the rice on each division separately and compare the yields.

NOTE. This experiment can be carried out best where the water supply can be controlled by irrigation. In other sections it may be better to plant the seed at two-week intervals in the seed bed and transplant the seedlings of different ages all at the same time.

CHAPTER XI

THE COCONUT

FIG. 68. A well-kept coconut grove, with trees planted in straight rows and the ground kept cleared.

THE coconut belongs to the palm family of plants. The betel-nut, buri, nipa, and rattan also are palms. The leaves of some palms resemble in shape the palm of an open hand; others are more like a feather. The palm family is of great value in the tropics. In dry regions the date is the most important of the palms, but in moist countries like the Philippines the coconut palm is by far the most important of its family. The most valuable product of the coconut palm is copra, the dried meat of the ripe nuts.

Varieties of coconuts. There are several cultivated varieties of coconuts; all of them except the macapuno are used

for copra. The following varieties are quite easy to recognize:

The ordinary coconut. The husk of the unripe fruit is some shade of green, red, brown, or yellow. The stem of the fruit is usually the same color as the husk. In shape the nuts vary from those that are round to those twice as long as thick. In size they may be small, medium, or large. At some future time, when these many types of ordinary coconuts are carefully described and named, a certain type will always be known by one name. At the present time the same variety is usually known by different names in different districts.

Red coconut (kalimbahin). The husk of the unripe fruit is brownish red. The water and meat of the unripe fruit are said to be a cure for dysentery.

Pink coconut (kalimbahin-lihim or "hidden-red"). The husk of the unripe fruit is green outside and pink inside. This coconut also is said to be a cure for dysentery.

Ivory coconut (guinaring). The unripe fruit has the color

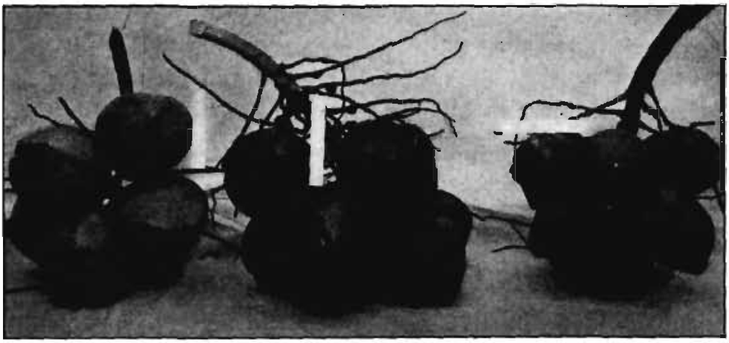


FIG. 69. Three types of coconuts: ivory, ordinary, dwarf (from left to right).

of old ivory. The leafstalks and fruit stems are lighter colored than the leafstalks of ordinary varieties.

Edible-husked coconut (tagnanam). The husk of the unripe nuts is sweet, like sugarcane, and is eaten chiefly by children.

Dwarf coconut (dahili, mongĩpod). The tree is used for yard decoration. The first bunches of nuts hang close to the ground and often contain forty or more fruits. The fruit is much smaller than an ordinary coconut and the shells are sometimes made into children's money banks.

Macapuno (" full "). The nut is of ordinary size. Its shell is nearly full of waxy meat, with often a small quantity of thick fluid near the center. A tree that produces macapunos also produces ordinary nuts; three out of seven nuts gathered from such a tree may be macapunos. The man who gathers the nuts knows which trees produce macapunos. The macapuno nuts are sterile and will not germinate, but the ordinary nuts grown on the same tree will germinate. The meat of the macapuno is too soft to be made into copra, but is highly prized for making coconut preserve.

Where to plant coconut trees. It is thought that coconut trees grow best along the seashore where the trees receive the salt spray, but the coconut trees at San Pablo in Laguna Province, thirty-two kilometers from the ocean, bear as well as any along the coast. From forty to eighty tons of copra are shipped from San Pablo daily. The successful growing of coconuts is largely a question of abundant water, food, and air for the roots; sufficient heat and sunshine for the leaves; and freedom from insects and injurious bacteria. The soil for two meters below the surface should not contain hardpan, gravel, or many stones. Usually soil that is near

rivers and sometimes flooded is the best. Sandy seashores and sloping plains that have higher ground near them are good. Soil near the base of old volcanoes also is good. A part of the water that falls on the highlands sinks into the porous soil and returns to the river or ocean by seeping down through the soil. It sometimes forms a spring at the base of the slope. Coconut trees growing on these slopes absorb a portion of this moving water. Districts with many cloudy, damp days are not good for coconut growing; the more wind and sunshine the better, providing the roots absorb sufficient water. The cost of labor, cost of land, and nearness to market should also be considered in deciding the location of a coconut grove.

FIG. 70. A good fruiting coconut tree, 30 years old.

Seed coconuts. Select seed coconuts from trees that are conspicuously heavier bearers than are near-by trees growing under similar conditions of soil and sunshine. A tree that bears well with other trees all around it is better than a heavier producing tree out by itself, or a tree on the edge of the grove, or one near a house. The nuts when gathered should be fully ripe. Such a nut is shrunken and has about half the water on the inside absorbed. To prevent the nuts

from cracking by falling, lower them to the ground with a cord. Cracked nuts never germinate. In case nuts are

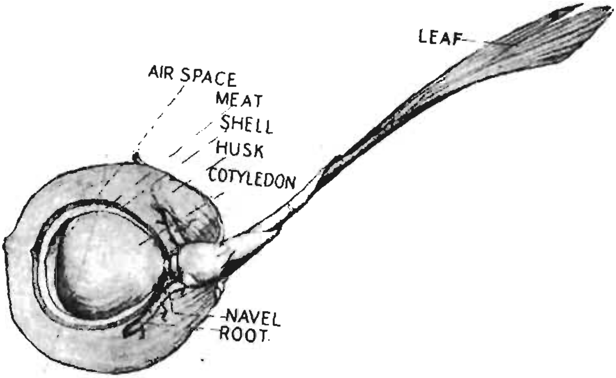


FIG. 71. A sprouted coconut, ready for planting.

gathered before they are fully ripe, they should be cured by being kept in a dry place well off the ground for about four weeks. During this time the husk shrinks and dries out, the water in the nut partly dries away, the meat hardens, and the amount of oil in the meat increases.

Raising the seedlings. There are several reasons why it is best to germinate coconuts before planting them: first, to hasten their growth; second, to allow the selection of the most vigorous seedlings; third, to protect the seedlings; and fourth, to shorten the time between permanent planting and fruiting. Two good ways for germinating the seed nuts are as follows:

The first way. At a place where soil and sunshine are suitable for a garden, lay out as many plots 120 centimeters wide as will hold enough nuts to give twice the number of

trees desired. Leave paths 1 meter wide between the plots. Till the plots, placing 15 to 20 centimeters of the topsoil in the paths. In the plots place the coconuts close together, each on its side, and fill the spaces between the nuts with topsoil, packing it in with a stick. Leave only 5 centimeters of the top of the nuts exposed. Cover the nuts 5 centimeters deep with loose grass or straw, and during the dry season water them twice a week. It is very important that the soil be well drained. If drainage is needed, dig a trench 40 centimeters deep to allow water to run away. This seed bed should be in the sunshine. Transplant the seedlings to the field when the shoots are about 15 centimeters high.[1]

FIG. 72. A healthy coconut tree, one year old.

The second way. For the seed bed select a place that is lightly shaded and well drained, and that is near to water. Till the soil thoroughly 20 centimeters deep and set the nuts close together, placing each on its side. Keep the germinating nuts moist. Nuts that have no shoot in sight after four months should be made into copra. According to the size

[1] During the period while the plant is changing its source of food supply from the meat in the nut to the food materials in the soil, the young plant is somewhat delicate and will probably die if disturbed. If it is not planted in the field before the shoot has reached 20 centimeters in height, it should be transplanted to the nursery until the roots have firmly established themselves in the soil.

of the shoots, the germinating nuts may be divided into three classes:

1. Those with shoots as large as the thumb.
2. Those with shoots as large as the middle finger.
3. Those with shoots as large as the little finger.

A large, healthy shoot indicates great vitality. Nuts with small shoots should be removed from the seed bed and made into copra. When the remaining nuts have shoots 15 to 20 centimeters long, plant them in the field. All nuts not planted should be immediately placed in a nursery and used later in filling vacancies in the field. Vacancies may be filled till the trees are ten years old. A tree used to fill a vacancy should be a little larger than the trees in the field, as it will take the transplanted tree some time to start its growth.

Nursery. The soil for the nursery should contain sufficient clay to be somewhat sticky, and should be well drained. If it is too sandy, many of the roots will be broken when the trees are taken up. Plow the soil several times, as deep as possible, and harrow it until it is soft and fine.

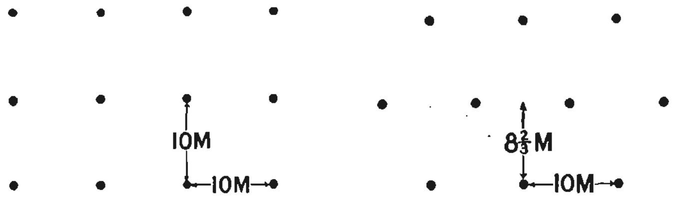
The nursery is now ready to be planted. Set the germinated nuts in straight rows one and a half meters apart each way, placing each nut either on its side or with the stem end slightly downward. After it is planted, the top of the nut should be on a level with the surface of the soil. Plants in the nursery should be allowed to receive the sunshine; for plants that grow in the sunshine have stronger stems and larger and greener leaves than plants that grow in the shade.

Cowpeas or sweet potatoes should be kept growing between the rows until the coconuts are two years old. When one crop is harvested, plant another; but do not replow the

soil, as this would break many coconut roots. Fence the nursery. For convenience in transplanting, the nursery should be near the planting ground.

For transplanting, select the most vigorous trees, discarding those with small stems and pale-colored leaves. If one half of each large leaf be cut off when a tree is transplanted, the tree will lose water less rapidly and the wind will not blow it over so easily. For suggestions on how to transplant, see below.

Staking out the field. It is very important that the trees be in straight rows and at equal distances apart. Before the



By Squares
Rows 10 Meters Apart

By Triangles
Rows $8\frac{2}{3}$ Meters Apart

FIGS. 73 and 74. Two ways of arranging coconut trees in the grove.

holes are dug, it is well to drive a stake into the ground where each tree is to be planted. The trees should be 10 meters apart. When the trees are planted 10 meters apart in squares, 100 trees can be placed in one hektar; but if they are planted 10 meters apart in triangles, 115 can be planted in one hektar.

Transplanting the trees. Where the trees are to be planted, dig holes 1 meter in diameter and 1 meter deep. After waiting a month or so for the soil to air, refill the hole with topsoil. After this soil has settled, plant the tree in the center of the filled place. The young plants should be taken up carefully from the nursery and planted on the same day.

FIG. 75. A coconut nursery with 25,000 coconuts.

Each seedling should be planted so that the nut at its base is just covered with soil. The best time to transplant the trees is toward the end of the rainy season.

Care of coconut trees. During the first four or five years, keep the soil within $1\frac{1}{2}$ meters of each tree tilled with the mattock. Do not allow grass or weeds to grow in this space and do not attempt to till this soil with a plow. The remaining space between the trees might be tilled with a plow or with a disk harrow and planted with upland rice, corn, cowpeas, sweet potatoes, mungo, or pigeon peas. Another system is to plant cacao, coffee, or lansones between the rows of coconut trees. The surface of the soil between the trees should be tilled 10 centimeters deep several times a year. During the dry season, maintain a soil mulch to keep the water in the soil. If grass and weeds are allowed to grow during the dry season, they will take a large amount

of water that should be left for the coconut roots. About 40 liters of water are absorbed daily by the roots of a thrifty

FIGS. 76 and 77. These two coconut trees were planted at the same time. The photographs were taken three years later. The tree at the left was planted in a hole the size of the nut. The tree at the right was planted where a hole had been dug 1 meter wide and 1 meter deep.

coconut tree, and an equal amount of water is given off by its leaves.

From time to time scatter manure or fertilizer on this soil and work it in thoroughly. The fertility of the soil should be maintained or even increased. Where tillage is not practical, keep the grass short by pasturing cattle. If coconut oil is sold from the farm, pigs may also be kept, as the oil-cake is excellent food for both cattle and pigs (page 66).

During the first year, roots grow out from the base of the tree to a distance of about 1 meter, and at two years to a

distance of 2 meters. The roots of a bearing coconut tree obtain most of their water and mineral foods within 50 centimeters of the surface. A full-grown tree has about five thousand long roots which extend in all directions for a distance of from 5 to 10 meters from the base of the tree. Each long root is about 1 centimeter in diameter.

Draining the soil. If the soil contains water that should be drained off, dig ditches, for coconut roots will die in stagnant water. Dig the ditch so that the water runs away slowly. In districts where the rainfall is not excessive, rain water may be prevented from running away by digging long, level ditches at right angles to the direction of the slope. The water soaks into the soil and is taken up by the roots.

The value of a coconut tree. A well-cared-for coconut tree begins to bear when about six years old, and it will be in full bearing at about twenty-five years. A farmer can well afford to give a tree the best of care, not only when it is young, but when it is bearing; for each well-cared-for tree will supply him annually with from forty to sixty nuts and will continue to bear for about eighty years. Some trees yield over two hundred nuts in a year.[1]

Harvesting the coconut. The best, the easiest, and the most profitable way to harvest coconuts is to pick the ripe nuts off the ground. A nut will fall when it is fully ripe. The ground beneath the trees should be kept cleared of shrubs and tall grass.

In some districts nuts are removed from trees by the use

[1] Copeland, in his book *The Coconut*, states that near Zamboanga he saw a tree yield 112 and 106 nuts at two successive cuttings only two months apart, and that less than two months later another similar crop was ready. The nuts were small, but the yield was at the rate of more than 100 kilos of copra a year.

of a curved knife fastened on the end of a jointed bamboo pole. These poles may be extended by pieces of bamboo about two meters long. The serious objection to this system is that nuts are almost certain to be gathered before they are dead ripe. An immature nut will not produce as much copra as a ripe one. Immature nuts should be cured before being made into copra. If cured too long, the nut begins to germinate, the meat then softens, and the oil in the meat decreases. A nut that is in the best condition for copra is also in the best condition for the seed bed.

FIG. 78. The curved knife used to harvest ripe coconuts.

The custom, common in some districts, of notching the stem of a coconut tree in order to climb it and harvest the nuts, has two serious objections. In the first place, it allows fungi (page 240) to enter, which cause the wood to rot (page 125). In the second place, the old leaves near the top of the tree are usually pulled off, exposing the tender stem. The stem then cracks and provides a place in which the palm weevil (page 127) sometimes lays its eggs and where the bacteria that cause bud-rot may enter (page 125).

Copra. Copra is the dried meat of the coconut. From it a valuable oil is extracted. The coconut meat is dried in many ways. The quality of the copra is graded according to the oil which can be extracted from it. The maturity of the nuts, as well as the way the meat is dried and handled, influences the quality of the copra.

FIG. 79. Open-fire copra drier. The coconut meat is placed upon bamboo slats and a fire is built underneath in a hole about 2 meters deep.

Maturing the nuts. If the coconuts are picked from the tree, the nuts should be stacked up off the ground for about three weeks before making them into copra. During this

FIG. 80. Sun-dried copra. Note the mats upon which the coconut meat is spread out.

time the nuts will ripen thoroughly and the amount of copra secured will be increased. Nuts that fall because they are dead ripe are mature and should be made into copra immediately. The meat can then be dried more easily.

FIG. 81. McChesney hot-air copra drier. Hot air from a furnace beneath the drier is driven through the steel box by a motor.

Drying the coconut meat. In certain districts of the Philippines, fresh coconut meat is dried by spreading it out in the sunshine. In other districts, the meat is dried and smoked by open fires. In dry weather high-grade copra can be made by the sun-drying method, but in cloudy, rainy weather the copra cannot thus be thoroughly dried and will not keep well. When dried by an open fire, the copra is darkened in color by the smoke and its value lessened. In Manila light copra is worth from one to one and a half centavos more per kilo than dark. It is estimated that during the year 1913 the coconut planters in the Philippines would have received ₱1,500,000 more for their copra had greater care been taken to secure a light-colored product.

Modern copra driers. Several attempts have been made to invent copra driers that with little expense will turn out a good quality of copra. In these driers the coconut husks and shells are used for fuel, and the copra is dried by steam pipes or by hot air. A drier that is not too expensive and

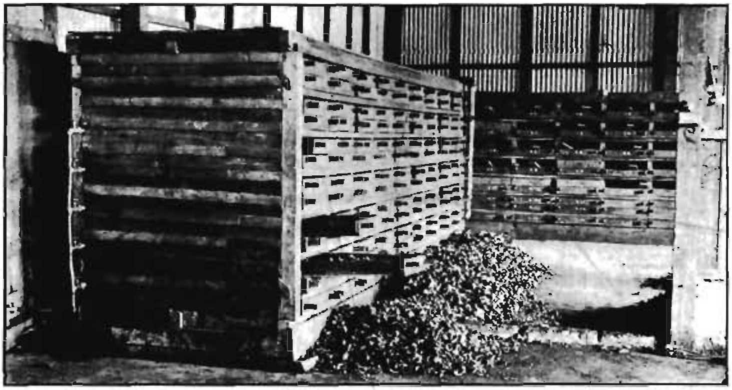


FIG. 82. Bonito hot-air copra drier. Heat is secured from pipes, through which steam passes.

that at all seasons of the year will produce first-class copra, will greatly increase the profits of the coconut growers.

Coir. Fibers in coconut husks are sometimes extracted and used in the manufacture of mattresses, mats, ropes, brushes, and sacks. The fiber is also used to calk boats. In some countries considerable quantities of the fiber are extracted, but in the Philippines little use is made of this by-product of the coconut. Machines are made for extracting the fiber, but they are adapted only to districts having 1,000,000 or more trees. From a thousand nuts about eighty kilos of fiber are usually obtained. To secure the best class of coir, the nuts must be harvested before they are fully ripe, and a smaller yield of copra is then obtained. A planter who harvests his nuts green for coir should determine carefully whether the value of the coir more than offsets the decrease in the value of the copra.

Loss of food materials from the soil. An average-sized coconut contains about 8.5 grams of nitrogen, 8.6 grams of

FIG. 83. Coconuts ready for shipment.

potash, and 2.4 grams of phosphoric acid. A coconut leaf contains about 11 grams of nitrogen, 27 grams of potash, and 9 grams of phosphoric acid. A tree that produces forty nuts in a year and loses sixteen leaves will take enough of these food materials from the soil to be worth about seventy-four centavos. It is evident, then, that if the nuts and leaves are removed from a coconut grove, the soil will constantly become poorer in the food materials that the trees use.

Returning food materials to the soil. The oil in the coconut meat is made from water absorbed through the roots and from carbon dioxid taken in from the air by the leaves. Since the oil does not contain the mineral food materials that are taken from the soil, a farmer who sells the oil and returns to the soil all other vegetable matter produced by the tree, is not

robbing the soil. If the oilcake (which is copra minus the larger part of the oil) is fed to horses, cattle, or other animals and the manure from the animals is returned to the soil, then the only loss in plant food materials will be that contained in the meat and bones of the animals. If the cattle are allowed to pasture away from the grove during the day and are tied to the trees at night, the fertility of the soil will be increased rather than decreased.

Oil in copra. It usually takes from three to four ripe nuts to make one kilo of commercial copra.[1] This contains from 3 to 25 per cent of water, 50 to 77 per cent of oil, and 25 to 45 per cent of oilcake. In 1913 there were exported from the Philippines 113,055,063 kilos of copra. Four fifths of this was sent to France, Germany, and Spain. There the oil is pressed out and used in the manufacture of soap and candles, and in foodstuffs that are used in place of butter and lard. Only oil from white copra, however, is used for food. The oilcake is fed to horses, cattle, and pigs, and the manure from the animals is worked into the soil.

Thinning coconut groves. A coconut tree, from a farmer's standpoint, may be said to do two kinds of work. It produces roots, stem, and leaves for itself, and it produces fruit for the farmer. The tree always works for itself first, and then if its roots can get sufficient food materials and its leaves enough sunshine, it will produce coconuts, which man can use.

In many coconut groves in the Philippines, the trees are too close together to produce fruit. The leaves of one tree shade the leaves of the next, and the roots of several trees are struggling together in the soil for the same water and food materials. None of the trees can get enough food to

[1] $63\frac{1}{4}$ kilos = 1 picul.

do more than remain alive; the farmer gets no fruit from any of them. The trees should be at such distances apart that the leaves will not touch each other, — about 10 meters each way is a good distance. It should always be remembered that the value of a coconut grove depends on the number of nuts it produces, and that crowded groves, even though they contain hundreds of trees, are of little value to their owners. When a tree becomes so old that it no longer bears, it should be cut out of the grove.

FIG. 84. A coconut tree with bud-rot disease.

Bud-rot in coconuts. The growth of a certain kind of bacteria in the bud of the coconut tree causes the bud to rot. The rot spreads until the entire top of the tree is destroyed and the tree dies. In Cuba and other parts of the world thousands of coconut trees have been killed by this disease. The bacteria are carried from tree to tree by the men that climb the trees, by insects, by birds, and by the wind. Trees just coming into bearing are most liable to attack. A tree affected with bud-rot has the following symptoms:

1. Falling of the young nuts.
2. Blackening of the flower stems.
3. Wilting and yellowing of the central unfolded leaf.
4. Soft, bad-smelling condition of the bud.
5. Falling of the young leaves while the old leaves remain on the tree.

A tree affected with this disease should be cut down; the leaves, nuts, bud, and all other parts from the top of the tree should be burned on the spot; and the stem and stump, together with a little lime, should be placed in a trench one meter deep and covered with soil. Close planting and moist air favor the disease, and climbing the trees spreads it rapidly through a grove. When the affected trees are promptly cut out, the disease can be controlled.

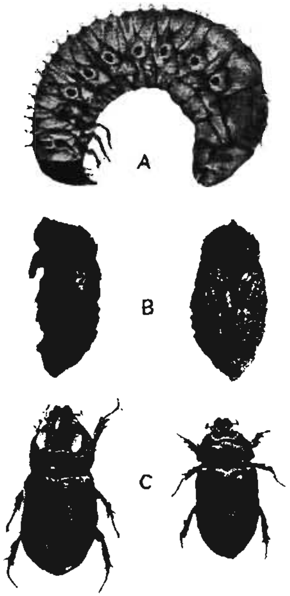


FIG. 85. Rhinoceros beetle (*Oryctes rhinoceros*). *A*, larva; *B*, pupa; *C*, adult beetle.

The rhinoceros beetle. The rhinoceros beetle (Fig. 85) in the adult stage makes holes in the coconut trees near the bases of the young leaves and feeds on the soft tissues of the bud. Affected coconut leaves appear to be trimmed as with shears. The leaves were injured while yet in the bud. The female rhinoceros beetle lays eggs in rotting tree stems that are standing or lying on the ground, in rotting stumps, and in piles of cane waste, manure, or other rotting vegetable matter. It takes about six months for this beetle to pass through its entire life. It flies at night and hides in the daytime, often in holes that it has made in coconut trees. By the use of a stiff barbed wire, it may be extracted from these holes and killed. To prevent other beetles from entering, and also to keep out the palm weevil, the holes should be filled with tar and cement, tar and sand, or concrete.

The best way to combat the rhinoceros beetle is either to clear away all decaying vegetable matter where the adult beetles can lay eggs or to trap the insects. To trap them, dig on each hektar of land in the coconut grove a pit 3 meters square and 75 centimeters deep. Fill the pit with vegetable matter, such as coconut stumps, banana stumps, leaves, or cane waste, and then cover the pit over with large leaves to hold the moisture. Every six weeks dig over the piles, and kill the beetles and larvæ that are found in them. It is very necessary either to bury in the soil or to submerge completely in water, all dead trees, logs, and decaying vegetable matter, excepting the piles of vegetable matter used as traps. Coconut logs should not be used in bridges or in buildings, as the insects will breed in them. If all vegetable matter except that in the traps is cleared away, the number of beetles can in a measure be controlled.

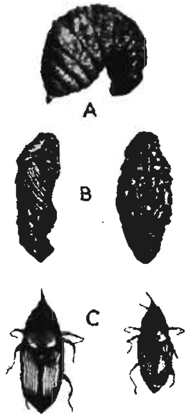


FIG. 86. Asiatic palm weevil (*Rhyncophorus ferrugineus*). *A*, larva; *B*, pupa; *C*, adult weevil.

Asiatic palm weevil. When the tender stem at the top of a coconut tree is exposed, a palm weevil may alight there, make a small hole with its long snout, and deposit an egg at the bottom of the hole. It also may enter the hole made by a rhinoceros beetle to lay its eggs. Records show that one palm weevil will lay from one hundred to two hundred eggs in a month. When the eggs hatch, the legless larvæ eat the soft stem and bud and finally kill the tree. The top then falls. It takes several months for this insect to pass through its lifetime of egg, larva, pupa, and adult insect.

The palm weevil does not lay its eggs in an uninjured tree, but if the tree is notched for climbing, if the leaves are pulled from the tree so as to expose the tender stems, or if the tree is injured by fire or by storms, the weevil will attack it. The old leaves should be allowed to hang on the tree to protect the trunk, and the nuts should be harvested without climbing the tree. If a tree is attacked by this weevil, cut it down, burn the top to destroy eggs, larvæ, and adults, and bury the trunk and stump, submerge them in water, or burn them. All infected trees in a district should be destroyed.

Losses in coconut growing. The coconut tree may be attacked by bacteria or by insects, and the farmer sometimes loses his young trees by fire or through the ravages of wild hogs or other animals. These losses can in great part be prevented, and even now coconuts are the most profitable of all Philippine crops. The greatest losses of the coconut grower come from too close planting of the trees, harvesting green nuts, and producing smoked copra. As copra is a money crop, the farmer should use every effort to make all the profits possible on his labor and on the money that he has invested in his land and trees.

EXERCISES

Exercise 47. To show the advantage of digging large holes for coconut trees. Near the school and where farmers who pass by can see them, plant 4 rows of coconut trees, each row containing 4 trees. If school land is not available, some farmer will give permission to plant them on his land. For the first and third rows of trees, dig holes only large enough to bury the nut. For the second and fourth rows, dig holes as directed on page 116. Set the trees 10 meters apart. Watch the growth of the four rows of trees.

Keep the soil near the trees properly tilled. The soil should be good for coconuts and should not be shaded.

NOTE. This experiment should be performed, even if only two trees are used.

Exercise 48. To study the effect of close planting on the yield of coconut trees. Visit neighboring coconut groves. Note places where the trees are 3, 4, or 5 meters apart and those where they are 10 meters apart. Observe the yield of nuts under these conditions and compute what the yield per hektar would be with trees planted at these distances.

Get permission to thin a section of a grove and cut out the trees as nearly as possible to 10 meters apart. Watch the trees and note if the yield is increased. The increase in nuts, if any, will not be noticeable until two years after the thinning.

Exercise 49. To determine the best time for gathering coconuts. Gather 20 well-ripened coconuts that have turned brown (nuts that have dropped off themselves are best). Gather at the same time 20 coconuts that have not turned brown, but which the farmers consider suitable for making copra. Make copra from each of the two lots separately and weigh the copra.

Exercise 50. To show the advantage of ripening nuts that are cut green from the trees. Select 40 coconuts that have not ripened. Make 20 into copra at once. Place the other 20 on a platform off the ground and allow them to ripen for 3 weeks. Then make them into copra. How does the copra made from the two groups of nuts compare in weight?

NOTE. The water in the immature coconut is rich in food material. When the nut ripens, much of this food material is built into the solid meat of the nut.

Exercise 51. To determine the profits on close planting and open planting. If coconut trees are planted 5 meters apart, how many trees are on a hektar? If each tree bears 5 nuts per year, what will be the yield per hektar?

When trees are planted 5 meters apart, each tree occupies 25 square meters of soil. There are 10,000 square meters in one hektar. If the trees are planted 10 meters apart, how many trees are on a hektar? If each tree yields 50 nuts, what will be the yield per hektar?

Which grove could be planted at less expense?

CHAPTER XII

ABACÁ

FIG. 87. Transporting abacá from the mountains to the coast towns.

ABACÁ is the principal export crop of the Philippines. Only in these Islands does the abacá plant flourish, and the whole world depends on the Philippines for its supply of the fiber. It is used chiefly in the manufacture of rope, and for this purpose no other fiber is so good as abacá. It is also used extensively in the manufacture of twine, and from the finer fibers of the inner petioles beautiful cloth is made. It is an excellent money crop for the Filipino farmer, and because it is their chief export crop its successful cultivation means much to the Filipino people as a whole.

The abacá plant. The abacá plant (*Musa textilis*) and the banana plant are very much alike. One difference, however, is that a banana leaf is blunt at the end, while an abacá leaf

is pointed. The valuable fibers are found in the petioles of the leaves. The overlapping petioles of the 16 to 26 leaves

FIG. 88. An abacá plantation, showing mature plants.

form what is called the *stalk*, which is from 2 to 5 meters high. The real stem of the plant remains very short until the plant is ready to bear fruit. It then grows up through the center of the stalk and bears a cluster of fruit similar to the banana. The fruit contains many seeds and is of no value for food.

Varieties of abacá. There are fourteen or more varieties of abacá. They differ in the color and size of the leaves, in the color, size, and shape of the stalk, in the number of suckers produced, in the yield and strength of the fiber, and in the ease with which the fiber is extracted. A good abacá plant should be hardy and should grow rapidly. It should withstand drought and produce a large quantity of first-class fiber which is easily extracted. Under favorable conditions, certain varieties yield a large quantity of strong fiber, while others produce only a small quantity of weak fiber. Usually several varieties can be found growing in each abacá district. A study of each kind will determine its good and its weak points.[1]

Good conditions for growing abacá. Abacá requires air that is warm and moist. Places where strong winds prevail are not desirable locations for abacá fields; but if other conditions are favorable, the winds can be controlled in a measure by planting windbreaks. Tamarind, mabolo, or mango seedlings planted one meter apart in a row make an excellent windbreak. Top the seedlings when they are one meter high to thicken their growth.

Abacá grows best in light, well-drained, moist soil. The loose, well-drained soils that have been formed near volcanoes are the best of all for abacá culture. As a rule, the more decaying vegetable matter in a soil the better; for this makes the soil lighter and causes it to hold more water. Do not burn vegetable matter when preparing land for abacá or any other crop. Cut it down and leave it on the ground to decay and form a mulch. Water in the soil is of first importance;

[1] For further information consult Farmers' Bulletin No. 12 (revised edition), published by the Bureau of Agriculture at Manila.

the supply can be controlled by vegetable and soil mulches, by drainage, and by irrigation. Each farmer must determine which plan is best for his land.

Unless there is a heavy vegetable mulch, the soil between the rows should be tilled. It is very important that the topsoil be kept loose and free from growing weeds. The drier the season, the more often the topsoil should be tilled. The abacá waste and the blades of the leaves should be cut into small pieces and worked in with the soil. They will thus return to the soil the food materials which the plant took from the soil to produce them.

Planting abacá. Abacá can be reproduced from seeds, from suckers, or from the underground stems of old plants.[1] The seed should be planted in a garden plot of well-prepared soil that is half shaded until the seedlings are up, after which shade is no longer necessary. Keep the soil moist. Abacá is not often raised from seed, because it takes from six to twelve months longer to produce mature plants in this way than from either suckers or stems. Suckers are planted singly. When the large stems of old plants are used, they are usually cut into two or more parts.

The soil of the field where the plants are to be set should be tilled thoroughly with a mattock or with a plow. Set the plants from $2\frac{3}{4}$ to 3 meters apart. With a long string mark the place for each plant and dig there a hole 50 centimeters deep and 50 centimeters in diameter. Just before planting, fill the holes with topsoil. Set a plant in the middle of each filled place, packing the soil carefully around the plant. If the land is cleared and can be cultivated without the soil washing away, grow a crop of mungo between the rows. Sweet pota-

[1] See Book I, page 33.

FIG. 89. Abacá plants fifteen months old. Cowpeas were turned under for green manure before the abacá was planted.

toes or other food crops may also be planted in a new field. The topsoil must at all times be kept loose and should contain an abundance of decaying vegetable matter.

Harvesting abacá. Stalks grown from suckers or stems will be ready to cut in from twenty to thirty-six months, while stalks grown from abacá seed will not be mature until some time later. The fibers of a stalk are of most value from the time just before the flowers appear until the fruits develop. During this time the stalks should be cut and the fiber stripped. If cut either before or after this period, the fibers will be of less value. Cut the stalks with a slanting blow near the base, leaving the stumps with slope enough so that rain water will not stand on them. Be careful not to injure the young plants. Stalks can be cut from an old abacá plant two or three times a year. With proper care the plant will keep

reproducing new stalks by sending out suckers for from ten to twenty years, or even longer.

Stripping. The petioles of the leaves contain the fibers. The outer petioles contain coarser and darker colored fibers than the inner ones. The outer portion of each petiole contains the best fiber, and can be separated in long strips from the remaining soft tissue of the petiole. To separate the fibers from the softer tissues, these strips are drawn under the edge of a knife held against a block of wood. The wet fiber is then spread out in the sunshine to dry. When dry it is ready for the market. On rainy days the fibers may be hung over a cord or wire under a roof. If not dried within a few hours after being stripped, the fiber darkens in color and is less valuable. Some knives for stripping abacá have a smooth edge, while others have a rough edge like a fine saw. With the smooth knife a whiter and better grade of abacá

FIG. 90. Stripping abacá: first process.

can be produced, and with the rough knife a larger quantity. Each planter must study the problem carefully and deter-

FIG. 91. Stripping abacá: second process.

mine by the prices offered for the different grades of abacá, together with the cost of stripping, which grade of abacá is most profitable for him to produce. Many attempts have been made to invent a machine that will strip abacá, but as yet none of these machines is a success.

Grading abacá. "Hemp" is the commercial name under which abacá fiber is known on the market. In many markets, the term "Manila hemp" is used. In grading abacá, the color, strength, and absence of pulp are the qualities that are usually considered. The soil and climate, the variety of abacá and the position of the petiole in the stalk, the manner of stripping, drying, and handling the fiber, all help to determine the grade of the abacá. When the fiber is dry, the farmer should separate it carefully into different grades, as he can then get a higher price from the buyer. He should examine samples of different grades and learn their market prices.

EXERCISES

Exercise 52. To select a desirable variety of abacá. Secure a tract of land and divide it into long plots. Make as many plots as there are varieties of abacá in the neighborhood. Plant each plot to a different variety, care being taken that each plot contains the same number of plants.

As the stalks mature, strip the fiber and weigh it. What is the total amount of salable fiber produced on each plot? What is the quality of the fiber of each plot? Compare the income from each plot.

NOTE. It will take several years to work out the experiment satisfactorily.

Exercise 53. To determine the best method of propagating abacá. Divide a tract of land into two equal plots. In one plot plant stems of old plants 3 meters apart at places where holes 50 centimeters deep and 50 centimeters in diameter have been dug and refilled with topsoil. It is best to have the holes dug and left exposed to the air a month or so before they are refilled. In the other plot plant, in a similar manner, suckers of the same variety as the rootstocks. Cultivate both plots alike, and plant cowpeas, mungo, or peanuts between the rows. After three years compare the two plots as to rapidity of growth, number of hills in each plot, and size and number of stalks in each hill.

NOTE. This experiment should be carried out on land near the schoolhouse, so that the plot may be visited by successive classes.

Exercise 54. To become familiar with different grades of abacá. Secure samples of different grades of abacá from an abacá buyer. Have members of the class bring small bunches of the abacá that is being produced in their homes. Compare these with the samples of the buyer.

Exercise 55. To determine some of the factors involved in the production of high-grade abacá. Take 4 abacá stalks of the same

variety and of about the same size; weigh each; separate them into fibrous ribbons. Weigh the ribbons from 2 of the stalks and strip them, being careful that the apparatus is well adjusted, and that the knife presses evenly upon the block of wood. As soon as the fiber is stripped, spread it out on a line where it will be exposed to the sunshine and wind. When it is thoroughly dry, weigh it and determine its grade and price.

Weigh the fibrous ribbons from the other two stalks, leave them in the shade for two hours, and then strip them, using the same apparatus, but changing the adjustment so that the knife will be looser than in the first stripping. Tie up the wet fiber and place it in the shade for a few hours. Later, spread it out on the line where it will be exposed to the sunshine and wind. When it is thoroughly dry, weigh it and determine its grade and price. Compare the two samples of fiber with respect to weight, grade, color, strength, cost, and value.

CHAPTER XIII

SUGARCANE

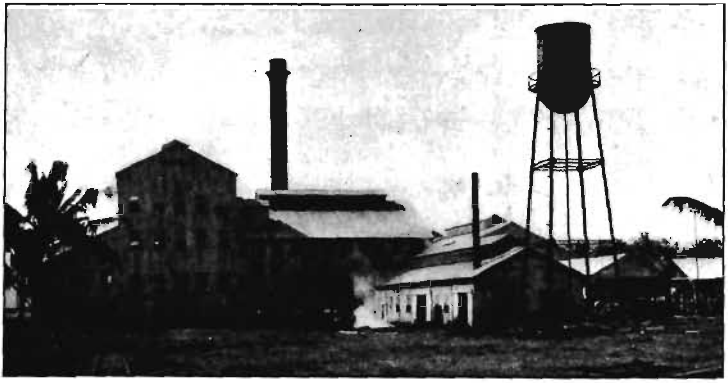


FIG. 92. A modern sugar mill: the Sugar Central at San Carlos, Occidental Negros.

AMONG Philippine crops, sugar stands fourth in value and third in importance as an export crop. There is much good sugar land in the Philippines, and sugar will become an even more important crop in the future. The introduction of machinery is making its production more profitable, and the amount exported rose from 112,000,000 kilos in 1909 to 213,000,000 kilos in 1913. There is always a market for sugar, for it is a standard article of food and the world uses almost 20 billion kilos of it a year. A little more than half of this is secured from sugarcane and the remainder from the sugar beet.

Sugarcane. Sugarcane (*Saccharum officinarum*) is a member of the grass family and greatly resembles certain wild

grasses that grow in the lowlands. There are many varieties of sugarcane, which, for purposes of study, may be classified into those having red, green, white, purple, striped, or blotched stems. Some stems are soft, while others are hard. Sugar-

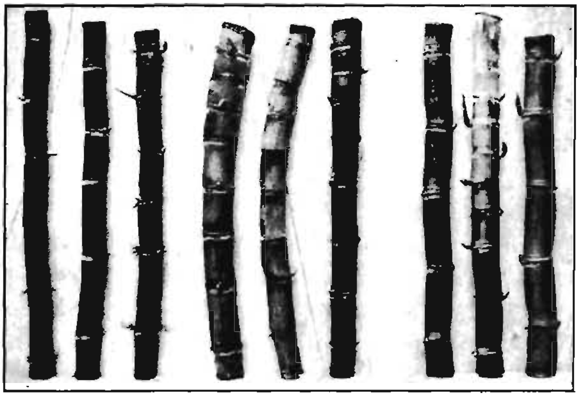


FIG. 93. Three varieties of sugarcane.

cane grows in tropical and subtropical climates, Java, Cuba, Hawaii, and Louisiana being the most important sugar-producing regions. In Europe and in parts of the United States, great quantities of sugar are also made from the sugar beet.

Study of a cane plant. Dig up a sugarcane plant, wash the soil from the roots, and observe its leaves, stems, buds, and roots. The stem continues below the surface of the soil. Notice where the roots are attached. How many nodes are on one stem? The portion of the stem between two nodes (Fig. 94) is called an *internode.* Are the internodes all the same length? At each node is a bud, and near the bud is a circle of dots that indicate where roots will grow. A leaf was attached at each node.

At a node, cut a section of the stem one centimeter long, peel off the outside and chew the inside. Is it sweet? Cut another similar section halfway between two nodes and chew it. Which of the two pieces is sweeter? Which is harder? Will a stem one meter long with long internodes contain more sugar than a similar stem with short internodes? Which stem will grind more easily in a mill? A cane plant that grows rapidly will form longer stems with longer internodes than one that grows slowly.

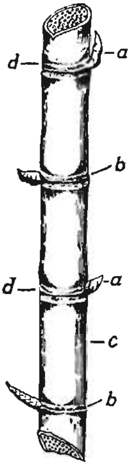


FIG. 94. Parts of a stem of sugarcane: *a*, buds, or eyes; *b*, dots where roots may grow; *c*, internodes; *d*, nodes.

Good soil for sugarcane. Almost any rich soil that is cultivated deep will produce a good crop of cane provided the water supply can be controlled. After the soil of a field has been made fine and all weeds have been killed, deep furrows 150 centimeters apart are made. In these the "seed" is planted. In case the land slopes so that the topsoil is liable to wash, make the furrows at right angles to the direction of the slope. If planting is done during the dry season, each furrow should be irrigated just before the cane is planted.

On the large sugar plantations of Hawaii the soil is sometimes tilled as deep as 120 centimeters with steam plows. However, profitable crops are secured where there is but 20 centimeters of soil.

Sugarcane "seed." The young plants are started from cuttings of the stem that are called *seed* or *points*. These cuttings should be taken from the tops of the best stems

that grow from the healthiest plants.[1] Keep them in a dry place in the shade until it is time to plant. In the dry season place the cuttings in clear running water for from one to three days to start the buds. Just before planting the cane, remove the leaves. Some farmers prefer to keep the cuttings in water for only one day and then to place them in a pile in the shade and cover them with grass for from seven to fourteen days. When planting, set each cutting at an angle of forty-five degrees. Push it into the soil at the bottom of a furrow, leaving only the tip exposed. Place the cuttings 45 centimeters apart. The cuttings may also be laid flat in the bottom of the furrow and covered with soil. The soil near the cuttings should be kept moist but not wet. As the shoots grow, refill the furrow with loose soil.

Drainage. When sugarcane is grown on level land that does not have a porous soil, dig ditches 50 to 100 centimeters deep, so that after a storm water will not stand on or near the surface. Keep the ditches cleaned out, as it is very important for the roots of sugarcane to have abundant air.

Tillage. While the cane is growing, cultivate the soil between the rows every few days. This is very important during a dry season. Pull up weeds that grow close to the cane and keep 6 centimeters of the topsoil loose. In a light soil or in any well-tilled soil, the goose-neck hoe can be used to advantage. Usually the crop is not cultivated after the cane shades the ground so that weeds do not grow. Cane is then said to be "laid by." Some farmers keep the lower

[1] There is a disease of sugarcane that causes pink streaks to appear in the inside of the stalk. Cuttings that are infected with this disease will produce diseased plants with a small amount of sugar.

FIG. 95. Cultivating sugarcane with the Philippine plow.

leaves stripped from the stems, but the best planters avoid this expense. Deep cultivation is injurious: it breaks the numerous fine roots with which the soil is filled.

The time for harvesting. Sugarcane should be cut and milled when it contains the largest amount of sugar. This is sometime between the tenth and thirteenth months after planting. The exact time can best be told by a chemical analysis of the cane. Whether a sugarcane planter who harvests 2000 tons of cane annually has a profit of ₱10,000 or a loss of ₱5000, may be determined entirely by the degree of ripeness of his cane when it is harvested. The sugar chemist can help the sugarcane planter to learn when his cane is ready to be harvested. The sooner the juice is extracted after the cane is harvested, the greater the amount of sugar that will be obtained. In Java the sugar mills run night and day, and only enough cane is cut each day to supply the mill for the next twenty-four hours.

Extracting the juice. The cane is passed through rollers which crush it and squeeze out the juice. In the Philip-

pines, about 25 tons of cane are produced on a hektar. This amount contains about 3.4 tons of sugar. Even with the best mills it is not possible to get all this sugar out of the cane; but the large mills that carry the cane through a number of rollers save much more of the sugar than do the small mills.

How large a mill a sugar planter can afford to buy depends on the amount of cane that he harvests. Nevertheless, many Philippine planters would profit greatly by buying better mills at once. This the following facts show: One hundred tons of cane contains about 13.62 tons of sugar. A three-roller mill will leave 5.11 tons of this sugar in the cane, a five-roller mill 2.79 tons, an eight-roller mill 1.08 tons, and an eleven-roller mill 0.68 ton. If a planter has 100 hektars of sugarcane, how much sugar will he save by using a five-roller instead

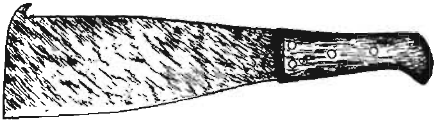


FIG. 96. A good knife for harvesting sugarcane. Length, 50 centimeters. The hook serves to remove leaves and to bring the cane near the laborer.

of a three-roller mill? What is the value of this sugar? If a three-roller mill costs ₱6000 and a five-roller mill ₱10,000, is it profitable for a planter with 100 hektars of cane to purchase a five-roller mill?

Evaporating the water from the juice. After the juice is pressed out of the cane, the sugar is obtained by evaporating the water of the juice. This is sometimes done by boiling the juice in open pans under which fires are built, but only the lowest grade of sugar is made in this way. A better grade

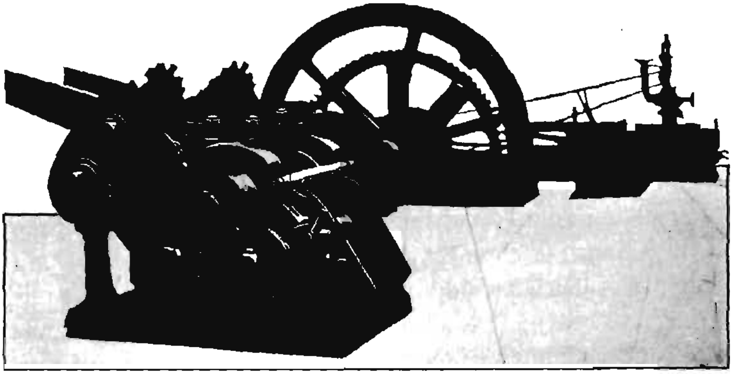


FIG. 97. A five-roller sugarcane mill with gearing and engine.

of sugar is made with vacuum pans. In these the juice is heated by steam pipes and is not burned.

Sugar centrals. A large sugar mill can get more of the sugar out of the cane than a small mill can get, and can make a better grade of sugar. The best plan for the small planter, therefore, is to take his cane to a large mill. This may be a central mill that is owned by all the farmers of the community together, or the mill may be owned by a separate company which buys the cane from the farmers. The cane is weighed at the mill, a chemist determines how much sugar is in it, and each farmer is paid according to the amount of sugar that he brings to the mill.

Other products from cane. Next to sugar, the principal product of cane is molasses. Molasses contains sugar and other substances, like gums, that are in the juice of the cane. It is sometimes fermented and made into an alcoholic drink.

FIG. 98. A good way to carry sugarcane from the field to the mill is by iron cars run on a portable track.

Increasing the yield of sugar. The most important work for the Philippine sugar planter is to increase the yield of sugar per hektar. This he can do by the selection of improved varieties of cane and by better cultivation.[1]

Proper rotation of crops, deeper plowing before the cane is planted, and shallow tillage while the cane is growing, are also necessary for a large yield.[2] Still more important is the

[1] In Hawaii one large plantation produced a crop that averaged $28\frac{2}{5}$ tons of sugar per hektar. Certain fields yielded $34\frac{1}{4}$ tons per hektar, and a small plot at the experiment station produced at the rate of $39\frac{1}{2}$ tons per hektar. The yield on the average plantation in Hawaii, however, is about $12\frac{1}{2}$ tons per acre.

[2] The following rotations are practiced in Java:

1. Cane, ground provisions, rice, ground provisions, rice, cane
2. Cane, ground provisions, rice, cane
3. Cane, rice, ground provisions, rice, cane
4. Cane, rice, ground provisions, cane, rice, cane

In "ground provisions" are included peanuts, beans, corn, cassava, and yams. Irrigation is practiced, and the rice and ground provisions are both grown in one year.

FIG. 99. Two plots of sugarcane. One was irrigated and the other was not.

control of the soil water. During the wet season the fields must be ditched and thoroughly drained, and during the dry season the fields should be irrigated if possible. Where irrigation is not practicable, a surface mulch of loose soil must be kept on the fields to prevent the evaporation of the water from the ground.

It is also important that an abundant supply of vegetable matter be kept in the soil. In Hawaii the leaves of the cane are laid between the rows and buried by throwing two furrows of earth on them. This adds vegetable matter to the soil, and also returns to the land the food materials that are in the leaves.[1] Sugar, like coconut oil, is made from water and carbon dioxid, and selling it does not carry away the food materials from the land. The ashes from the sugar mill

[1] When the leaves are burned, the vegetable matter in them is destroyed and the nitrogen in the leaves escapes into the air. Each leaf contains 0.033 gram of nitrogen, which should be kept for succeeding crops.

should be carefully saved and returned to the land; for they are rich in phosphoric acid and potash. The cane from which the sap has been taken is called *bagasse*. This also is good to put back on the soil, as it contains foods which the plants took from the soil.

The use of fertilizers on sugarcane. A little oilcake sprinkled in the furrows before the cane is planted gives the young plants a good start. Sulfate of ammonia used at the rate of 1 kilo to 40 square meters of land may also be a profitable fertilizer. It is applied after the plants are growing and is worked into the soil with a cultivator. Freshly slaked lime used every other year at the rate of 1 kilo to 8 square meters improves most land for sugarcane production. The use of fertilizers in the Philippines is not yet well understood, and a planter must learn by experiment how profitable their use will be to him.

EXERCISES

Exercise 56. To study desirable types of sugarcane. Visit a sugarcane field. Look for vigorous plants that send up a large number of strong stems with long internodes. Discuss with intelligent farmers desirable points that are to be kept in mind when "seed" is selected.

Exercise 57. To study the process of sugar making. Let the class visit a sugar mill and observe the different processes in sugar making. Discuss with the class the problems connected with getting all the juice out of the cane and of making a high-grade sugar.

CHAPTER XIV

CORN

FIG. 100. One of the great corn fields of Kansas.

WHEN Columbus visited America, the Indians gave him bread made of grain called *mahiz,* and in letters to his friends in Spain he told them about eating a new grain called *mahiz* or *maiz.* Since in Europe the seeds of all small grains such as wheat, barley, millet, rye, and oats are classed as corn, this grain grown by the Indians was called *Indian corn.* To-day it is still called Indian corn, and corn. In many parts of the civilized world it is called *maize.* It was brought to the Philippines from Mexico by the Spaniards many years ago. The botanical name for corn is *Zea mays.*

Corn as a food. As an article of food corn is one of the most extensively used grains in the world. It is an excellent food

for man and domestic animals. There are many ways in which corn is prepared as food. In Mexico 90 per cent of

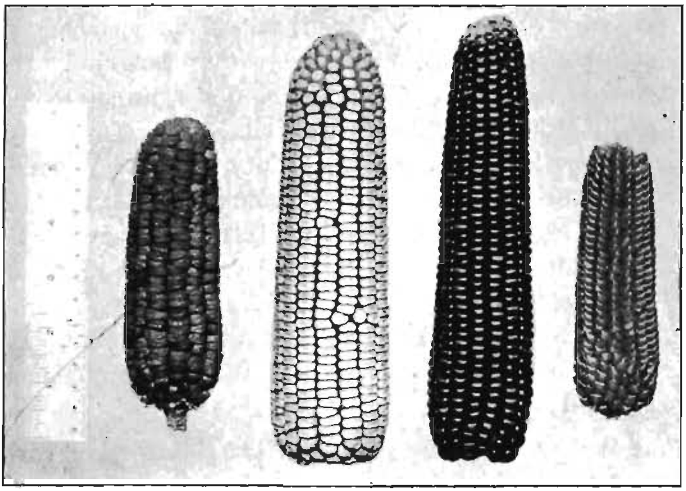


FIG. 101. Four types of corn — sweet, dent, flint, and pop (from left to right).

the natives use corn bread as their principal food. Corn is an important food in Italy. In many other parts of the world corn meal is made into mush, bread, and cakes. In money value, corn is fifth in importance among the crops of the Philippines, and every year it is becoming more important.

Kinds of corn. The kernels of corn are colored black, blue, brown, white, yellow, or red. There are four principal types of corn, and each of these again is divided into many varieties. The following are the principal types:

1. *Flint* corn has hard, smooth kernels. There are many varieties of flint corn, as white flint, yellow flint, and red

flint. Practically all the corn raised in the Philippines is of the flint variety.

2. *Dent* corn, when ripe, has a dent or depression in the crown of each kernel. This is caused by the drying and shrinking of the starchy matter within the grain. Dent corn is softer than flint corn, and its grains are more easily attacked by the corn weevil.
3. *Pop* corn is a small, extremely flinty variety. When dry, the kernels pop open, or turn inside out, on being heated. The plants, ears, and kernels of this variety are small.
4. *Sweet* corn is rich in sugar and shrivels when ripe. It is eaten in the green state just before the grains harden. Then the kernels are full, but soft and milky. It is cooked and served on the cob. It is also cut from the cob and canned.

Time to plant corn. As a rule, the best time to plant corn is either at the beginning or at the end of the rainy season. Where the land can be irrigated, the seed may be planted during the dry season. In districts of the Philippines where the rains are evenly distributed, it may be planted at almost any time. It matures in from three to four months and will grow in any district that has warm nights.

Soil for corn. Corn grows best in loam soil that contains abundant decaying vegetable matter. It grows well on soil where a crop of cowpeas, mungo, or other legume has recently been plowed under. The roots of corn need abundant air and will die in soil that is saturated with water.

Preparing the soil. The soil should be well plowed; all vegetable growth should be turned in, and the soil made reasonably fine. Excellent crops have been secured where the plow loosened the soil to a depth of 15 centimeters. After the

soil is plowed, it should be harrowed to break the clods and to make it level. Mark the soil into rows 1 meter apart in two

FIG. 102. A field of corn in Kansas.

directions and plant the seed where the lines cross. This will make the hills 1 meter apart and will allow the rows to be cultivated in two directions. Corn may also be planted in drills. Single grains are planted 30 centimeters apart in the row.

Planting the seed. In a hill plant 3 kernels, 10 centimeters apart; cover the seed with fine soil and tamp it lightly, so as to

press the soil against the seed. No definite rule can be given as to the depth that corn should be planted, but in general it is found that from 3 to 5 centimeters is best. A good general rule is to plant seeds just deep enough for them to get sufficient moisture to germinate. If planted too deep in wet, clayey soil, the seed will die for lack of air. It is sometimes advisable to soak the seeds overnight before planting them. Small fields may be planted by using the hoe, but in larger fields a hand planter or a drill will be cheaper. Just as soon as it can be determined that a hill has no plants, it should be planted again.

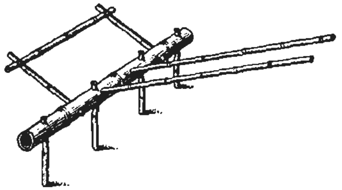


FIG. 103. A homemade marker, which can be drawn by a man. The teeth are 1 meter apart.

Cultivation. After the field is planted, harrow the soil twice during the first week. Use a light harrow that will stir only the topsoil. While the corn is growing, keep the topsoil in the field loose to allow air to get to the roots and to prevent water from escaping from the soil. The drier the season, the more necessary it is that the topsoil be tilled and that a soil mulch be maintained. If the soil is hard, the first cultivation should be deep; but after the plants are 30 centimeters high, the cultivation should be shallow. If the soil is tilled too deep, the corn roots will be broken, the growth will be checked, and the crop of corn reduced. Weeds should not be allowed in a corn field. The best tool to loosen the soil between the rows is a cultivator. The soil close to the plants had better be tilled with a goose-neck hoe. Neither of these tools, however, can be used to advantage in a field where there are large, hard clods. When the ears begin to form, all cultivation may cease.

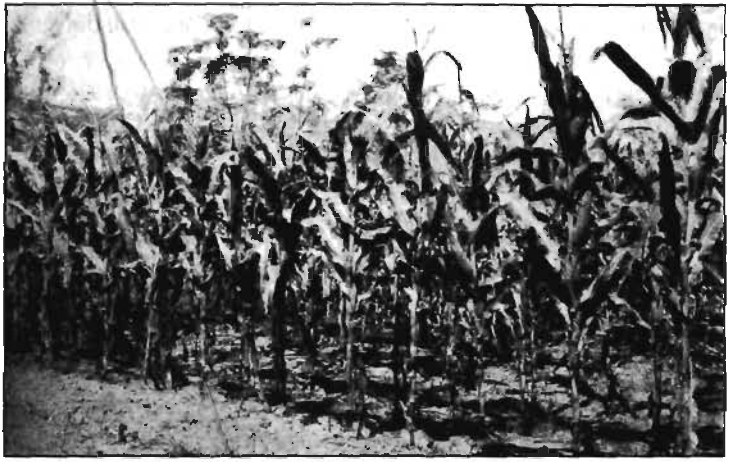


FIG. 104. Moro corn, grown in the dry season at the Singalong Experiment Station in Manila.

Plants that are not going to grow ears should be cut down. The remaining productive plants will then receive more sunshine and more water and plant food. At the last cultivation it is sometimes advisable to plant mungo, sincamas, cowpeas, or some other legume between the rows of corn. This, however, is not advisable unless there is sufficient moisture in the soil for both crops. The legumes add plant food to the soil.

Seed selection. The proper time to select seed corn for the next season's planting is just before harvest time. Go out into the field and select good ears from good healthy stalks. Save these ears for seed. The following points should be noted:

1. Select good ears from the most productive plants. A plant may produce one or more good ears. The ears should be attached near the middle of the stalk and when mature they should hang downward to shed the

rain. The stalk should be strong and upright; it should be large at the base and gradually become smaller toward the top. An extra large plant is usually more valuable for fodder than for grain.

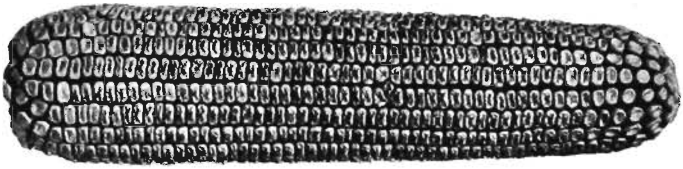


FIG. 105. The Pascal ear, the champion ear of corn in Iowa in 1908. This ear sold at auction for ₱ 3000.

2. The husks should fit tightly over the end of the ear.
3. The ear should be thoroughly ripe.
4. The ear should be cylindrical in shape or slightly tapering.
5. The butt (stem end) and the tip (other end) should be well filled with kernels. The grain should extend well out on the tip, but it is not essential that the tip be completely covered.
6. An ear of from 14 to 18 rows is desirable.
7. The rows of kernels should be straight.
8. The ears should be selected from hills that have a full number of plants.

A plant may have produced a good ear because it stood alone and not because it was in itself an especially productive plant.

As a rule, better corn will be produced by improving the corn now grown in a district than by planting imported seed. Before planting time select six grains from different parts of

each ear and plant them in coarse sand. Select for seed the ears that give the highest percentage of germination and the most vigorous seedlings. Plant *only the large seed from each* selected ear. Discard the small kernels from the tip.

Harvesting. If it is desired to save the corn leaves for fodder, pull them from the plants, and after drying place them in a pile to cure. Great care should be taken that only the green leaves are used and that they be not pulled until after the milky juice in the kernels has disappeared.

FIG. 106. The ears of well-selected corn are attached near the middle of the stalk. The stalks on the left will be easily broken by the wind because the ears are too high.

When the corn is ripe, gather the ears, leaving the husks on, and place the ears on a frame or platform to dry. The husks protect the corn from weevils. When the ears are dry, shell them and store the corn. Shelled corn that is thoroughly dry may be kept indefinitely in insect-proof tanks, or in earthen jars, or in clay ovens. Weevils in corn may be killed by carbon bisulfid. Leave the husks on the ears that are later to be used for seed.

Marketing. A part of the corn grown should be used as food by the family. Frequently the most profitable way to

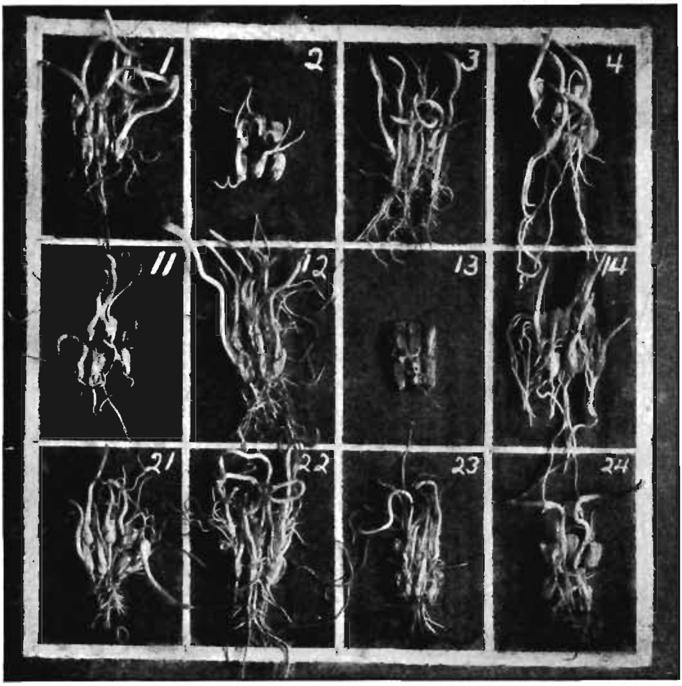


FIG. 107. A section of a germination box. Ears 2, 11, 13, and 24 should be immediately removed and carried to the feed bin, for fear they might get mixed with the others by mistake. Ear 2 is weak. One kernel has not sprouted at all, only swollen a little. Ear 11 shows one dead and one weak. Ear 13, six dead kernels, Ear 24, three dead kernels. Ears 21 and 23 are weak and slow and should be put to one side and not used unless absolutely necessary. Ears 1, 3, 4, 12, 14, and 22 show up strong and are now ready for butting and tipping. Ears like 2, which show some life, if planted, will be behind and probably produce little or no grain. The plants will produce pollen and the tendency will be to reproduce its kind, causing the corn to deteriorate instead of improving.

market corn not needed for human food is to feed it to hogs, poultry, or cattle. The meat of the animals may be eaten or sold.

FIG. 108. One of the ways to keep corn in the Philippines. Leaving on the husks prevents weevils from getting at the corn.

Black larvæ on young corn leaves. A small dark or brown moth flies at night and lays its eggs on the leaves of corn. In from three to five days the eggs hatch and the tiny black larvæ begin feeding on the leaves. In some fields only a few leaves are destroyed, but frequently all the plants are eaten.

When full grown, the larvæ are about two centimeters long; they then enter the soil and in a few days pupate. They may be destroyed by a poison made by mixing one part by weight of arsenate of lead with four parts of flour or air-slaked lime. Place the poison in two cloth bags and attach one to each end of a stick. By jarring the stick poison may be applied to two hills at a time.

Another good way of killing the larvæ is to mix one part of the poison with fifty parts of cooked rice bran and then to scatter the mixture around each plant. The larvæ will eat the poisoned mixture.

Cut-worm. A certain larva, called a *cut-worm*, cuts down corn seedlings. Cut-worms often become so numerous in the soil of a field that a good stand of corn cannot be secured. The simplest remedy is to plow the soil and plant some leguminous crop, after which corn can once more be profitably grown.

The corn pyralid. The larva of the *corn pyralid* often eats the inside of the stems of corn plants and injures them. At the present time there is no remedy known; but in selecting seed, be careful to avoid taking ears from plants attacked by this insect.

A score card for corn. The score card is an outline and explanation of the points that are to be looked for in judging corn. It assists the person who judges corn to recognize the ears that have desirable characters. Each variety of corn will have a different type for a standard, and each district must determine what it considers a perfect ear. A perfect ear should score 100 points, and if all five ears of an exhibit are of the same type, the exhibit as a whole should score 100 additional points. The highest possible score for an exhibit, therefore, is 600 points. Each ear should be scored by itself, and for any imperfections the judge must subtract something from the score.

The following instructions for the application of the points on the card are given:

1. *Market condition* (20). This is shown by the soundness of the grain and the freedom of the grain from dark spots, adhering particles of husks, or shriveled appearance.

2. *Purity of grain color* (5). All grains on an ear should be of the same color. Kernels should be free from mixture with corn of another color. Mixture in yellow corn is shown by the

SCORE CARD

No.	Scores	Value	Credits Ear No. 1	Credits Ear No. 2	Credits Ear No. 3	Credits Ear No. 4	Credits Ear No. 5
1.	Market condition .	20					
2.	Purity of grain color	5					
3.	Shape of ear . . .	10					
4.	Length to circumference	5					
5.	Butt of ear . . .	5					
6.	Tip of ear . . .	5					
7.	Space between rows	10					
8.	Per cent grain to ear	15					
9.	Trueness to type .	10					
10.	Shape of grain . .	5					
11.	Uniformity of grains	5					
12.	Weight of ear . .	5					
	Total	100					

Credits given ear No. 1 ....
Credits given ear No. 2 ....
Credits given ear No. 3 ....
Credits given ear No. 4 ....
Credits given ear No. 5 ....
Total credit of the 5 ears ....

13. Uniformity of exhibit (possible credits 100) ......
Total credits for exhibit ....

white on the crown of kernels; in white corn, by the color on the sides of kernels. Each kernel lacking should be considered of another color. For each mixed kernel $\frac{1}{8}$ point should be cut from the score given that ear for purity of grain color.

3. *Shape of ear* (10). A good ear should be round and almost as large at one end as at the other. The ear should be straight

and not much enlarged at the butt. Rows should be straight.

4. *Length to circumference* (5). The proportion of length to circumference varies with the different varieties. The preferred length would be about one and a half times the circumference taken near the middle of the ear.

5. *Butt of ear* (5). The butt should be even and well rounded and should extend a little beyond the end of the cob. The grains should not vary greatly in shape and size. The place of attachment of the ear shank should be of moderate size.

6. *Tip of ear* (5). The grains should be of fair size but need not necessarily cover the entire tip.

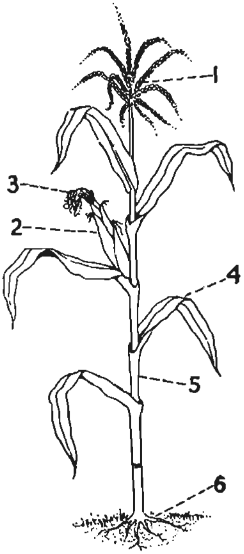


FIG. 109. Parts of a corn plant: *1*, tassel; *2*, ear; *3*, silk; *4*, leaf; *5*, stalk; *6*, roots.

7. *Space between rows* (10). The low places between rows of grains are called *spaces* or *furrows*. The deeper and wider these spaces are, the poorer the ear. Deep spaces imply rounded grains — a condition which means less grain to the amount of cob.

8. *Per cent of grain to ear* (15). Medium or small cob and long grains indicate much grain on the cob and are, therefore, desirable.

9. *Trueness to type* (10). Each ear of an exhibit should possess the qualities common to that variety.

10. *Shape of grain* (5). The ideal kernel is of a wedge shape, with the grains of one row touching those of the adjacent rows

throughout almost the entire length. The kernels should be long and not too much shriveled at the crown or large end.

11. *Uniformity of grains* (5). The grains should be of uniform size and shape, except the kernels near the extreme tip and butt. There should be a certain amount of uniformity in the grains.

12. *Weight of ear* (5). This refers to the weight of the ear after being thoroughly dried. The standard or ideal weight should be greater in case of one-eared variety of corn than in the case of two-eared varieties.

13. *Uniformity of exhibit* (100). All ears of an exhibit should be uniform in size and appearance. An exhibit usually consists of 5 ears.

Value of score card. The score card assists the beginner to see the desirable qualities of a good ear and the undesirable qualities of a poor one. After using the score card a few times, one can judge corn better without it. The score card is only for the beginner.

EXERCISES

Exercise 58. To make a field study of corn production. Take trips with the pupils to the corn fields of neighboring farmers and observe the growing corn. Have the pupils set down in their notebooks the facts given in regard to the soil, the distance between rows, and cultivation. Visit the field again at harvest time and note the yields secured. Compare the yields with the soil conditions and the cultivation given the crop. Inquire concerning seed selection.

Exercise 59. To learn to judge corn. Bring 50 ears of corn to school and attach a number to each ear. Have each pupil select the 5 best ears. Use the official score card. After all have finished, compare the scores given. The corn judged should all be of one

variety. After the judging is completed shell the five ears and weigh the corn from each ear separately.

Exercise 60. To determine the best way of storing corn. Secure 30 ears of corn in the husk. Remove the husks from 10 of these ears and hang them where they will get the smoke from an open fire. Leave 10 ears in the husks and hang them where they will receive strong light. Shell 10 ears and dry the grains thoroughly. Store the shelled corn in a tin-lined box or jar that is weevil-proof. Keep this box in a dry place. From time to time examine the corn stored by the three methods. See which one keeps free from weevils the longest time.

Exercise 61. To show the value of a soil mulch on growing corn. Plant two plots to corn so that the crop will mature during the dry season. Keep the 6 centimeters of topsoil of one plot thoroughly cultivated. Allow the other to bake, but pull or cut the weeds from the plot. Note the effect of the soil mulch on the growth of the corn.

Exercise 62. To select a high-yielding strain of corn. After the soil of a field has been plowed and harrowed for corn and marked off into rows 1 meter apart, select 20 rows near the center of the field. The longer the rows the better.

Get 10 good ears of Philippine corn. Number each row and each ear. Plant rows Nos. 1 and 2 with kernels from ear No. 1; rows Nos. 3 and 4 with kernels from ear No. 2, and in a similar manner the succeeding rows.

Watch the corn as it grows, and when it can be determined that a stalk is not going to yield a good ear, cut the stalk down. Any stalk that appears to lack vigor or seems likely to produce a small ear should have the tassel cut off before the pollen matures. The pollen from poor stalks will thus be prevented from fertilizing ears on other stalks.

When the corn is harvested, keep separate the ears from each row. Select 10 of the best ears from the 2 best rows and keep them for seed. Repeat the experiment for several years, until a

good strain has been secured. Stalks that bear 1 good ear are more desirable than those that bear 2 small ears. Any good ears that are not needed for continuing the experiment may be used in planting the regular crop.

NOTE. The teacher should make sure that the class understands the importance of cross-pollination in corn. A corn plant from a grain of a good ear may have as one parent a stalk that had no ear. The farmer must keep the pollen from these inferior stalks away from where seed corn is growing. His seed corn must have a good father as well as a good mother.

CHAPTER XV

TOBACCO

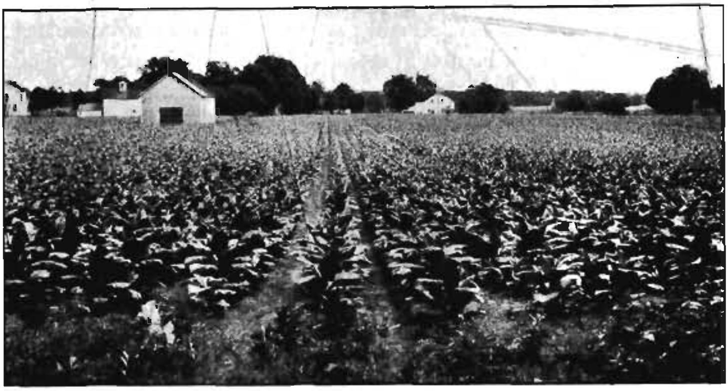


FIG. 110. A Connecticut tobacco field.

TOBACCO is grown in nearly all parts of the world where the conditions of soil and temperature are favorable. Four or five months of warm and somewhat dry weather are essential. The leaves and stems of tobacco are prepared in various ways to be smoked, chewed, or snuffed. The leaves and stems contain a poisonous substance called *nicotine,* named after Jean Nicot, a Frenchman, who introduced tobacco into France in 1560.

Since tobacco is not a food and its use is a luxury, the government taxes those who manufacture and sell it. During the year 1913, over ₱5,000,000 were thus collected in the Philippines. In many sections of the Philippines it is the main money crop.

The tobacco plant. The tobacco plant (*Nicotiana tabacum*)

belongs to the same family as the tomato, the potato, and the eggplant. There are many varieties of tobacco, but the flavor of the leaf is determined largely by the soil in which it is grown and the influences of climate. These vary in different parts of the earth, and the tobacco from different countries has different qualities. The most noted tobaccos are the Sumatra, the Cuban, and the Turkish.

Sumatra tobacco. The region where the famous Sumatra tobacco is grown is close to the Equator. There the temperature is high and even, and the rainfall abundant during certain seasons. This tobacco is specially valued for outside wrappers of cigars. It is light brown in color, and is thin and elastic.

Cuban tobacco. The Cuban tobacco has an especially desirable aroma and flavor when it is used for smoking. It is used largely for the inside part of cigars and is known as *filler tobacco*. Considerable wrapper tobacco also is grown in Cuba.

Turkish tobacco. In Turkey the conditions are just right to produce a small, fine-flavored leaf. The growing of Turkish tobacco and its manufacture are controlled by a private company which has a monopoly. Turkish cigarettes, with their characteristic aroma and flavor, are famous throughout the world.

Other varieties. In a great many localities in the temperate and torrid zones, tobacco is grown. Many localities have their varieties. Tobacco seed grown in one district is often shipped to a distant land and planted, but unless conditions are alike in both places a different class of tobacco will be produced.

Tobacco in the Philippines. A fair grade of tobacco can be grown in all parts of the Philippines, and an excellent quality can be produced in certain localities where the soil, the rainfall, and the wind are favorable. The most certain way of telling

what grade of tobacco a certain district will grow is to make a trial. The best soil for tobacco is usually found in the lowlands, where the rivers, during a flood, have brought down and left on the land a rich deposit of fine soil. Almost any light soil that is well drained and properly tilled and manured can be made to produce a good crop. As a rule, a light sandy soil produces fine, thin, elastic leaves, and a heavy soil produces thick, heavy leaves. The most famous tobacco district in the Philippines is the Kagayan valley in northeastern Luzon.

FIG. 111. The small plant grew in soil that was not manured; the two large plants in soil that was manured.

Raising the seedlings. Tobacco seeds are planted in seed plots, and later the plants are transplanted to the field. Before planting the seed, spread dry grass or brush over the prepared plots and set fire to it. The fire heats the soil and kills certain microörganisms that may later destroy the tobacco seedlings. When the soil is cool, work the ashes into the topsoil and plant the seed. The seed should be mixed with either ashes or lime, so that thin and even sowing will be easier. The sowing is best done with the fingers. Keep the soil moist. Shade the plots until the plants are up. When the plants are 2 or 3 centimeters high, transplant them to a plot prepared as for growing vegetables. Set them 3 centimeters apart each way, and later transplant them to the field. If only a small number of plants are required, the seed may be planted in germinating boxes.

FIG. 112. The tobacco seedlings at the left were grown from large seeds. The tobacco seedlings in the center were grown from medium-sized seeds. Those at the right were from small seeds.

Transplanting to the field. The soil in the field should be plowed and harrowed as for corn and then marked off into hills, from 75 to 90 centimeters apart. The greater the distance between the hills, the larger and coarser the leaves will grow. Just as soon as the soil is ready, transplant the seedlings to the field, placing one in a hill. If the soil is dry, water the place where each plant is to be set. The best time to transplant is on a cloudy day or late in the afternoon. The young plants should be shaded. If a plant does not do well, put a fresh one in its place. The growing plants should be tilled the same as corn.

Pruning the plant. Since the leaves are the valuable part of a tobacco plant, it is important to know that their growth can be controlled, in a measure, by pruning the plant. If the tip of a plant is removed just before the flowers appear, together with the shoots that later grow in the axils of the leaves, the remaining leaves will become darker in color and heavier. If the plant is allowed to grow unpruned, the leaves will always be lighter

FIG. 113. Philippine tobacco improved by selection.

and thinner. It requires considerable experience to know how to prune a tobacco plant so that the leaves will be of the most value. The work differs with the variety of tobacco, the climatic conditions, and the fertility of the soil. The vigor of the plant and the quality of the leaf desired must also be kept in mind.

As the leaves ripen, they will hang down and change in color from a dark to a light green; they should then be harvested and later "cured," "fermented," and "aged." Leaves should not be gathered when wet or when the sun is hot. They should mature during a season when there is little if any rain.

Caring for the leaves. The object of curing, fermenting, and aging tobacco is to develop in it a desirable flavor and aroma. The curing process allows the leaves to die, as it were, accord-

FIG. 114. Hands of tobacco arranged for exhibit.

ing to rule. Fermenting allows them to heat and decay slightly. The aging process changes them slowly; during this process the tobacco leaves are placed in bales and kept for one or two years in a room of uniform temperature. To secure certain additional flavors, various substances, as rum, sour wine, oil of anise seed, powdered cloves, cinnamon, or licorice, are sometimes added to the tobacco during the fermenting and aging process. As a rule these artificial flavors are not added to tobacco manufactured in the Philippines.

Marketing tobacco. Tobacco demands the closest attention of any money crop grown in the Philippines. The crop must be well cared for while growing. Even after a good harvest of excellent tobacco has been secured, the profits are not assured. The quality of the marketed product will depend upon the care taken in handling the harvested leaves. After

the leaves are cured, they must be graded according to quality and size and then be put up in uniform "manos" (hands). The tobacco must be in a well-cured condition when put up into manos, which should be neatly made in a manner to furnish the greatest protection for the leaves. The tobacco is usually sold to buyers in this form. Before the leaves are manufactured into tobacco products in the factories, the manos must be stored until they have gone through a sweating, or fermenting, process, after which they are placed in bales, which are pressed compactly in a press and wrapped with some covering to protect the tobacco.

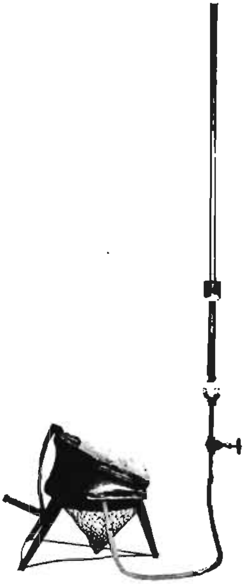


FIG. 115. A machine to separate small tobacco seeds from large ones. With the bellows air is forced up through the glass tube. The light seeds in the tube are blown out at the top. The large, heavy seeds remain in the tube.

Tobacco products. Tobacco is placed on the market in the form of cigars, cigarettes, chewing tobacco, smoking tobacco, and snuff. Large factories employ thousands of people to prepare these products for the market. The chief by-product of a tobacco factory is tobacco dust, which is used by market gardeners to kill plant lice and by farmers as a manure.

Seed selection. The easiest way for an ordinary farmer to increase the value of his crop of tobacco is to secure seed from first-class tobacco plants and to use them in the production of his next crop. Such seed might be secured from some farmer

in the neighborhood who makes a specialty of raising tobacco seed, or from the Bureau of Agriculture at Manila. If a farmer grows his own seed, he should visit different parts of his fields to become thoroughly acquainted with the growing plants, and then, when the tobacco is topped, allow the flowers on a few choice plants to remain and produce seed. Each flower of tobacco produces pollen to fertilize its own ovules, but insects will bring to it pollen from other flowers also. This cross-pollination in tobacco is not desirable, and to prevent it the flowers on the plants selected for seed should be covered, during the pollination period, with paper bags. First remove all the shoots, leaves, and small branches immediately below the cluster of flower buds and then, before the buds open, cover the head of buds with a paper bag, tying it securely to the stem. Every three or four days remove the bag, break off the new shoots, and then replace the bag. When the flowers are all fertilized, remove the bag and allow only about thirty of the best fruits to mature. When these are ripe, remove the cluster of fruits, together with ten centimeters of the stem, and hang them in a dry place where the wind circulates freely. Later, when the fruits are dry, clean the seeds, separate the heavy seeds

FIG. 116. A tobacco plant with the flowers covered with a sack to prevent cross-pollination.

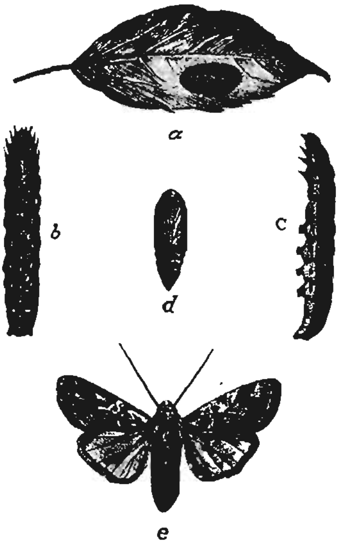


FIG. 117. Life history of the tobacco worm: *a*, eggs; *b* and *c*, larvæ; *d*, pupa; *e*, adult moth.

from the light ones, and store the heavy seeds in dry bottles or in tins until planting time.

The tobacco worm. The brown moth (Fig. 117) of the tobacco worm lays its eggs in clusters on tobacco leaves. The eggs are sometimes laid also on the leaves of the tomato, corn, rice, cabbage, sweet potato, or the castor plant. In three days the eggs hatch and the young larvæ begin to eat the leaves. After eighteen days each larva crawls down into the soil to change into a pupa. Nine days later the adult moth crawls out from the pupal case and at night flies about. The female moth lays its eggs on some leaf and, after three days, dies. The best way to control this insect is either to pick off the larvæ and eggs by hand or to place poison on the leaves. The larvæ are sometimes destroyed by birds or by a disease that attacks them.

EXERCISES

Exercise 63. To demonstrate the proper method of making tobacco hands. Have the pupils bring to school enough leaves of a good grade of tobacco to make 10 hands (manos). Let the pupils make the hands in a proper manner. Take these hands to a local dealer and find out whether they are prepared so as to bring the highest market price paid for that grade of tobacco. The tobacco

can then be returned to the owner. Enough tobacco leaves might be secured to have each pupil make a hand.

Exercise 64. To determine whether the seedlings from light or heavy tobacco seeds are more vigorous. Secure some tobacco seed. Separate the heavy seeds from the light ones. Plant the heavy seeds in one end of a tobacco seed bed. Plant the light ones in the other end. Give the entire seed bed good care. Note from which seeds the strongest and best plants were secured. This exercise should be carried on at the home of the pupil.

NOTE. Any farmer who wishes to have his tobacco seed cleaned should send it either to the Bureau of Agriculture at Manila, or to the Tobacco Experiment Station at Ilagan, Isabela. The Bureau will separate the heavy seeds from the light seeds free of charge, and will return the heavy seeds to the sender.

Exercise 65. To determine the effect of tillage on a tobacco crop. Divide a field of tobacco into two equal plots as soon as it is transplanted. Cultivate one plot according to the method that is used in the neighborhood. Cultivate the other plot as follows: Just as soon as the young plants have begun to grow, stir the topsoil between the rows with a cultivator or a plow. Continue to stir this soil at intervals of 8 or 10 days, until the tobacco becomes so large that there is danger of damaging it. As the plants grow large and the roots occupy the soil, only the top 6 centimeters of soil should be tilled.

Compare the two plots for height of plants and size and color of leaves. At harvest keep separate the leaves gathered from the two plots. Compare the leaves as to size, color, quality, weight, cost, and value.

Exercise 66. To test different methods of curing tobacco. When the tobacco grown in the community is being harvested, select some of the best leaves and string them in pairs on sticks. The leaves of each pair should be face to face. Place 15 pairs on a stick 1 meter long. Have the pairs of leaves an equal distance

apart. After 10 sticks have been filled with leaves, place them immediately inside of a curing shed. Choose a place where the air circulates freely. As the tobacco cures, observe it very closely. Compare the leaves with the tobacco cured in the old way for (1) brightness of color and (2) value as cigar-wrapper material.

Exercise 67. To study the curing of tobacco. Have the pupils visit the warehouse of a tobacco buyer and see how tobacco is cured. Have them observe the tobacco brought in for sale and note whether the quality has been reduced by worm holes in the leaves and by poor care in curing the tobacco. Emphasize the fact that both these defects are due to conditions which can be controlled by the farmer.

CHAPTER XVI

OTHER FIBER PLANTS

FIG. 118. Henequen in Yucatan, Mexico. Row of six-year-old plants in a field of exceptionally fine plants grown from suckers. Notice the straight rows, the absence of weeds, and the numerous suckers.

EXCEPT the food plants and possibly those that furnish timber, there are no plants that are so important to man as the fiber plants. From these plants he gets the material for his clothing, for his beds and pillows, for his ropes and cords, for his nets and sails, and for many of the other articles that he uses. Abacá is the best known of the Philippine fiber plants, but there are a number of others that also are important. These plants we shall discuss in this chapter.

Cotton

Cotton (*Gossypium*) is the most important vegetable fiber in the world. In the tropics it is especially valuable, for most

clothing is made of cotton. During the year 1913, cotton cloth and other manufactured cotton goods, worth ₱22,967,276, were imported into the Philippines, together with 284,700

FIG. 119. Weighing cotton with a steelyard.

kilos of raw cotton that was made into coarse cloth in the Philippines.

Cotton in the Philippines. The cotton plant grows well in the Philippines, and its fruit would yield abundant fiber if the weevils that destroy the fruit-buds or "bolls" could be controlled. Some time ago this insect threatened to destroy the cotton crop in the United States; but the scientific agriculturists there studied the problem effectively, and now larger cotton crops than ever are harvested. Considerable cotton is now grown in China. In the year 1586 cotton was exported from the Philippines, but the industry has been allowed practically to die out. At the present time there is little produced except small amounts in Ilocos Norte, Ilocos Sur, Batangas, and Union provinces.

Growing the crop. Some varieties of cotton should be planted farther apart than others, but in general the preparation of the soil before the seeds are planted and the care of the

FIG. 120. Picking cotton in the southern part of the United States. In the fertile lowlands of this region most of the world's supply of cotton is produced.

growing plants are the same as for corn or sugarcane. Cotton grows best in the lowlands in light, well-drained soil; it matures in from five to eight months and should ripen during the dry season.

Cotton fiber. The cotton fibers are packed about the seeds, and when the pod opens and the wind blows the cotton away the seeds are scattered about. The cotton fibers are so fine that single fibers cannot be used as threads in making cloth, but, as may be seen by looking at them under a microscope, they are flat and twisted. This makes it very easy to spin them into thread, and cotton is used more than all other fibers combined in the making of cloth. This is used for clothing, as sails for boats, and in many other ways.

Kapok

The kapok tree (*Ceiba pentandra*) is found in all parts of the Philippines and fruits especially well in districts that have a long dry season. It is valuable because it can be grown on rough land that is not suited to other crops. After the leaves fall the flowers open, and later the green, spindle-shaped fruits appear. When ripe each fruit is ten to fifteen centimeters long and filled with black seeds embedded in fine, silky fibers. The fiber from the ripe fruit is used to upholster furniture, mattresses, and pillows. It is considered good material for this, because it is very light and does not pack. Kapok is sometimes called tree cotton. However, it is not a true cotton. It belongs to a different family of plants. The fibers are short and are not twisted, and cannot readily be made into thread.

FIG. 121. A kapok tree in flower and fruit.

Planting kapok. The kapok tree is best grown from seed. The seed should be taken from mature fruits grown on trees which bear large quantities of first-class fiber. The trees from which the fruits come should be over five years old. Plant the seeds 2 centimeters deep and 4 centimeters apart in rows 30 centimeters apart. When the plants are 15 centi-

FIG. 122. Young kapok trees, with upland rice as catch crop.

meters high, pull out the weak ones, leaving the others not less than 10 centimeters apart in the rows. After 10 or 12 months the young trees may be transplanted. When they are transplanted, prune the stems back to a length of about 50 centimeters, remove all the leaves, and cut off most of the small roots. Set the plants 6 meters apart and cultivate the soil between the rows.

The kapok fruit. Without care kapok will produce some fruit, but with care it will produce large yields. The trees begin to bear about the third year. The ripe pods are gathered with a bamboo pole that has a hook on the end. The fully ripe fruits are brown. Open them immediately and place the uncleaned fiber in the sun. The fiber from green pods or from pods that have been wet too long is of poor grade and brings a low price. A large tree should yield about 3 kilos of cleaned fiber and 5 kilos of seed annually.

The fiber and the seed. In small quantities the fiber may be separated from the seeds and the core by pounding

with flails or with thin strips of bamboo on a slat floor. Where large quantities are grown, this work can be done cheaper by

FIG. 123. Ripe kapok fruits.

machinery. One hundred kilos of the dried ripe fruit contain about 18 kilos of fiber and 30 kilos of seed. At Manila, the cleaned fiber is worth about 70 centavos a kilo and the seed about 4 centavos a kilo. Both products are exported to Europe. One hundred kilos of seed will produce 25 kilos of oil for cooking purposes and soap making, and about 25 kilos of oilcake, which contains 4.40 per cent of nitrogen.

Maguey

Maguey (*Agave cantula*), sisal (*Agave sisalana*), and henequen (*Agave fourcroydes*) are all close relatives and all look very much alike. Maguey and henequen have spines along the edges of the leaves. The leaves of sisal are partially or entirely free from spines. All of them grow and are cared for in the same way, and the directions for growing all of them

are the same. In the Philippines, maguey is probably the most valuable of the three.

Where to plant maguey. In certain soils many different crops grow and produce abundant harvests. On other soils it is difficult to get any crop to grow. Maguey is valuable in the Philippines because it can be grown on land not suited to other crops. Another advantage is that the farmer can care for it and harvest it at times when he is not busy with his other crops. It can be planted on rocky soils, dry soils, cogon hills, in hilly regions, and in places where there is little money to buy work animals, farm implements, and machinery. It withstands typhoons, droughts, and locusts, and in years when other crops are lost maguey may be the farmer's main support. Maguey cannot be planted and harvested quickly, but by having it growing on what otherwise would be waste land, one can harvest and sell it when other crops fail. *The farmer who depends on several crops harvested at different times during the year, is more sure of making a living than the one-crop farmer.* There is much wisdom in the proverb which says, "Don't put all your eggs into one basket."

Raising the young plants. The plants are grown from either suckers or bulbils. The suckers grow from the base of the stems and appear after about the second or third year. If they are to be used for planting, the suckers should be dug up when they are 20 to 25 centimeters high. Some time after the eighth year, a plant will send up a flower stem. After the flowers wither and fall, the buds on the flower stems grow and develop into bulbils. The old plant dies after flowering. The bulbils are from 8 to 10 centimeters long. If they are to be planted in a field, they should first be set in a nursery for from 6 to 10 months. Set them 20 centimeters apart in straight

rows 40 centimeters apart. The soil in the nursery should be thoroughly tilled before the plants are set and afterwards frequently weeded. Both suckers and bulbils, if somewhat dry, may be shipped long distances.

FIG. 124. Maguey bulbils in nursery rows.

Transplanting. Plow and harrow the soil before the plants are set out. Where it is not possible to do this, till the soil with a mattock. All grass, weeds, and other vegetable matter should be piled up on the land to decay. It should not be burned, because decayed vegetable matter in soil is more beneficial to growing plants than are the ashes from the same plants. In the field set the plants 175 centimeters apart in straight rows 3 meters apart. Parallel roads 4.5 meters wide should be left every 50 meters for carts to pass at harvest time.

Cultivation. The maguey plant, the same as any other crop plant, grows better when the soil near it is kept loose and free from weeds. When possible, plow the soil between the rows and, from time to time, plant there some crop that will not shade the maguey. The problem of keeping vegetable matter in the soil is the same for maguey as for any other crop. Unless suckers are desired for planting, cut them off as soon as they appear.

Harvesting. Leaves may be harvested from planted bulbils after the fourth or fifth year, and from planted suckers about one year earlier. When the leaves are mature they contain the largest amount of fiber and the best fiber. Start

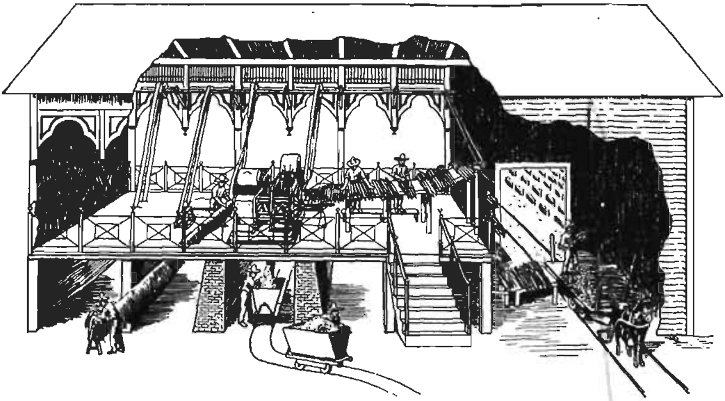


FIG. 125. Mill used in Yucatan for extracting henequen fiber.

harvesting at the beginning of the dry season. A plant will bear the largest number of leaves if the mature ones are kept cut off. With a sharp knife cut the leaves off close up to the stem and trim off the spines so that the leaves can be handled safely. From 20 to 30 leaves may be harvested from a good plant each year.

Extraction of fiber. The fibers in the leaves are separated from the pulp either by retting or by machinery. By the first method the leaves are split into strips, tied into bundles, and placed in salt water for from 6 to 8 days. The bundles are then removed from the water and the pulp scraped from the fibers. This process is slow and laborious and produces a weak, dark fiber. The best fiber is secured when leaves are cleaned by machinery, but to own even a small machine one should have at least forty hektars of plants. Machines clean from 10,000 to 200,000 leaves daily. In Mexico and in all other countries where henequen, sisal, or maguey are grown commercially, the leaves are cleaned by machines.

Drying and baling. The retted fibers should be thoroughly washed in running fresh water, for if salt is left on them, they later will absorb moisture and become discolored. Spread the wet fibers on lines in the sunshine to dry; on rainy days hang them on lines under sheds. When the fiber is dry, make it up into bundles about 10 centimeters in diameter, tying each bundle near the butt end. The bundles are then made up into bales of convenient size. The bundles in a bale should be laid straight, not bent at the middle. The fibers from the first leaves of a plant are not so good as those secured later.

Yield and value. The amount and the value of fiber produced by maguey plants depend upon the soil and climate, the distance the plants are set apart, the cultivation given, and the method of taking the fiber from the leaves. It is estimated that from 1000 leaves about 18 to 22 kilos of fiber can be obtained. At Manila maguey fiber is worth about 13 centavos a kilo, which is a lower price than for the poorest grade of abacá. It is estimated that the world's annual production of maguey, sisal, and henequen fibers is about 160,000,000 kilos, about 70 per cent of which is henequen from Mexico. These fibers are practically all made into twine, used by farmers in harvesting wheat and other crops that are cut and tied into bundles by machinery.

Pineapple

In some parts of the Philippines the pineapple (*Ananas sativus*) is grown for its fibers. Shade makes the leaves and fibers longer. Set the plants in shaded places, as below coconut trees. When grown in small numbers they are planted

FIG. 126. A pineapple field.

under banana or other plants that do not shut out too much of the sunshine.[1]

The fiber. Leaves may be harvested for fiber at about the time the plant fruits. Only well-matured leaves should be taken. These should be cut close to the stem with a sharp knife. The spines are removed from the edges of the leaves and then the leaf is divided into strips. The lower, or outer, part of the leaves contains the finer fibers. The divided sections of the leaves are scraped with a broken shell to remove the pulp. This work should be carefully done by hand in order that the fibers may not be broken. The fiber is then soaked in water overnight. It is washed and dried three different times before it is ready for use. A very fine cloth (piña) resembling silk is made from pineapple fiber. Farmers whose wives and daughters weave fine cloth as a household industry could profitably grow a small tract of pineapples for the fiber contained in the leaves.

[1] For additional information on pineapple cultivation, see Book I.

Buri Palm

The buri (*Corypha elata*) is a large palm which is found growing in many parts of the Philippines. It grows slowly and does not reach its full size until it is more than forty years old. Then the tree flowers, fruits, and dies.

FIG. 127. Cutting a petiole from a young buri palm, to get buntal fiber.

Planting and care. The buri palm grows best on well-drained soil. It will thrive on hills which will not produce ordinary farm crops. The buri is reproduced from seeds which are planted in a nursery. When the seedlings are of a suitable size, transplant them to the field. Set the plants 12 meters apart. The planting and the care of the young trees are the same as for coconuts.

Buri products. The buri palm furnishes a large number of products which are of value to the farmer. Mats, hats, and bags are made principally from the strips of the buri leaf. Buri raffia is obtained from the skin of the unopened leaf. From the midrib of the unopened leaf are taken the strips used in making hats. A strong and valuable fiber known as *buntal fiber* is secured from the petioles of the leaves. This fiber also is used extensively in manufacturing hats.

The sap of the buri palm contains a large amount of sugar.

When the plant begins to flower, the end of the flowering stem is sometimes cut off and the sap caught in a vessel. By cutting off a thin slice of this stem from day to day a large quantity of sap can be secured from one plant. Both sugar and a fermented drink are made from the sap.

Sabutan

Sabutan (*Pandanus sabotan*) is one of a family of plants known as *pandans*. It grows well on sandy soil along river banks and seashores where other crops do not grow. Sabutan is reproduced by cuttings. For a permanent planting set the plants 3 meters apart. The soil near by should be kept free from weeds and should be well tilled. In a few years the plant will produce a number of leaves, which are valuable to the farmer in the manufacture of mats, cushions, and hats. If a farm contains a strip of dry, sandy land, this land should be planted to sabutan.

EXERCISES

Exercise 68. To study the fibers produced in the Philippines. Secure samples of the fiber of abacá, maguey, kapok, cotton, buntal, and pineapple. Examine them for their fineness, length, and strength. Discuss with the class the uses of each. Which of these might with profit be cultivated more extensively in the community? Discuss the possibility of utilizing waste land for the production of some of these crops.

CHAPTER XVII

OTHER FARM CROPS

Castor Plant

THE castor plant (*Ricinus communis*) produces seeds that yield a valuable oil. This oil is excellent for use on leather and for lubricating machinery, and it is much used in medicine. The leaves of the plant are used as food for eri silkworms (page 204).

Varieties. There are many varieties of the castor plant, which in general may be divided into two groups, — the large-seeded and the small-seeded kinds. The large-seeded varieties yield larger quantities of seed and an oil that is suitable for lubricating. The small-seeded varieties yield a finer oil that is used in medicine.

Where to plant. Castor plants grow best on good corn land, but they can be grown profitably on cogon hills and on other waste land. This land can thus be made to produce something of value.

Planting the seed. The seed should be planted at the beginning of the rainy season. Prepare the soil as for corn, and mark off the field into hills 1 meter apart for the small-seeded kinds and 2 meters apart for the large-seeded. Plant 3 seeds in a hill, and later, when the seedlings are 30 centimeters high, thin to one strong plant in a hill. Before planting, soak the seeds in warm water for 24 hours. If the soil is dry, add water to each hill just before the seeds are planted. Keep the soil thoroughly tilled. If leaves are desired, remove the buds from the leading shoots when the plants are about 130 centimeters high.

Yield. The small-seeded variety ripens seed in from 4 to 5 months from the time of planting, and the large-seeded in

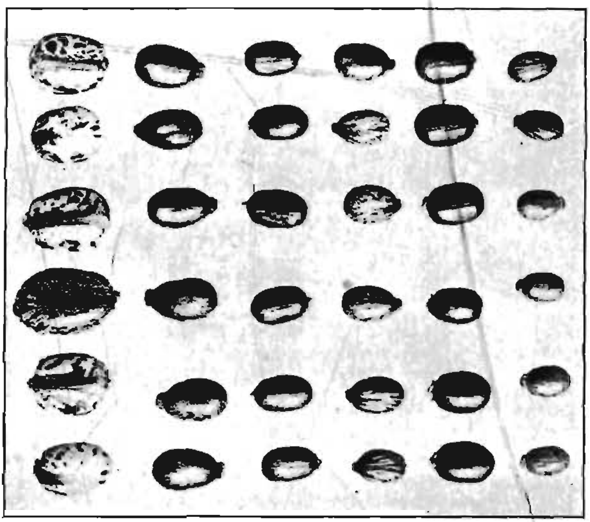


FIG. 128. Six varieties of castor seeds.

from 7 to 10 months. The fruits become hard and brown when ripe and they mature at different times. They should be gathered once a week and allowed to dry, after which the seeds can be separated from the pods. The yield from each hektar will be from 300 to 1000 kilos of seed. In Manila the seeds are worth about 8 centavos a kilo.

Pressing out the oil. The oil is squeezed from the seeds by first grinding them and then putting them under pressure. The crude oil is mixed with water and heated till the water boils, when the sticky matter in the oil rises to the top and can easily be removed. The oil is then strained through a cloth

and bleached in the sunlight. One hundred kilos of good seeds will produce about 41 liters of oil. The seeds should not be eaten as they contain a poison, three of them being sufficient to kill a person. The oilcake makes an excellent fertilizer.

About 4,000,000 liters of castor oil are used annually in the United States. The seeds are obtained largely from India, but they could be raised in the Philippines. When there is waste land on a farm, a plot of castor plants may well be put out. If the leaves are used for feeding silkworms, the profit will be increased.

Lumbang (Candlenut)

The lumbang tree (*Aleurites moluccana*) grows wild in most provinces of the Philippines. The wood is soft and white.

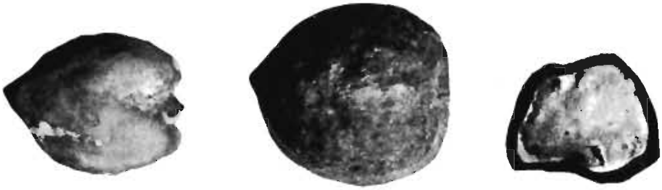


FIG. 129. Lumbang kernel, nut, and inside of a piece of shell.

This tree grows very large and bears great quantities of fleshy, egg-shaped fruits that are five to six centimeters long. Each fruit contains one or two hard-shelled nuts that are rich in oil.

Planting. The young lumbang trees are raised from the seed. Plant the kernels of the nuts in boxes, and when they have germinated plant them 10 centimeters apart in a garden plot. When the seedlings are 10 centimeters high, set them

FIG. 130. Crushing lumbang kernels. Notice the pile of lumbang oilcakes at the end of the whip.

in the field 12 meters apart. Dig the holes as for coconuts and till the soil between the rows the same as for coconuts. The trees begin to bear when about five years old and increase in yield until from 20 to 100 kilos of nuts annually are produced from a tree. The oil mills at Manila pay from 5 to 15 pesos a picul ($63\frac{1}{4}$ kilos) for the kernels.

Uses of the nuts. The kernels of the lumbang nuts are sometimes strung on thin strips of bamboo and burned like a candle, whence the name "candlenut." Each nut by weight is two thirds kernel and one third shell. The kernels are about 60 per cent oil. The oil is yellow, sirupy, and transparent. It dries in one day. In Manila its chief use is to paint canoes, cascos, large ships, and any wood intended for use under water, and in the manufacture of soap. It is also excellent for painting farm implements. At Manila lumbang oil is worth about a fourth less than coconut oil.

Lumbang oilcake is an excellent manure. It contains about

7 per cent of nitrogen, 3 per cent of phosphoric acid, and $1\frac{1}{2}$ per cent of potash. It is practically the only manure used by vegetable and betel-leaf growers in or near Manila. The round, thin cakes weigh about 930 grams each and are sold for from ₱6 to ₱14 a hundred.

Betel-leaf

The habit of chewing a betel-leaf with a small amount of lime and a piece of betel-nut has been a custom with oriental tropical people for many centuries. To give additional flavor various substances, such as tobacco, cloves, cardamom, nutmeg, and camphor, are sometimes added. As generally used this mixture, known as *buyo*, gives the chewer an untidy appearance, staining his lips, teeth, and gums. Cancer of the cheeks and mouth is especially common among buyo users.

Careful cultivation of the betel-leaf. Of the many plants raised by the Filipinos, there is not another one that is given such careful attention as is the betel-leaf. No pains are spared in providing the roots of this plant with abundant air, water, and food, and in giving its leaves and stems protection from insects, wind, and sunshine. The conditions for plant growth are made so favorable that on a very small area a large number of tender betel-leaves of just the right flavor are produced, and there are families near Manila that make a living by growing betel-leaf on garden plots not more than 25 meters square. The way the betel-leaf is grown and its wants provided for is the best example of scientific agriculture that is to be found in the Philippines. Other farmers, therefore, may study with profit the methods of the betel-leaf grower and learn from him how to care for plants.

Soil for betel-leaf. A rich, porous loam is necessary for the successful cultivation of the betel-leaf. Before planting, the soil of the plot should be dug 40 centimeters deep, mixed with compost, and then placed in piles to air for three months or more. In districts where the topsoil is very poor, the surface of the plot should be covered with from 10 to 30 centimeters of rich topsoil that has been airing in piles for at least three months.

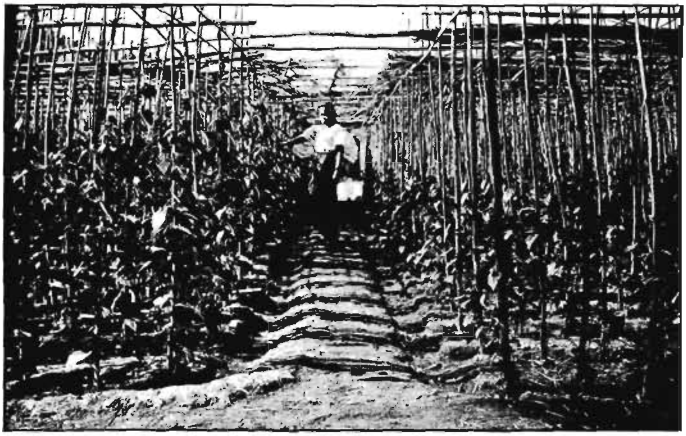


FIG. 131. Two betel-leaf plots. The ditches along each side of the path conduct water from the well to each row of plants.

Laying out a plot. The plots near Manila are usually 17 meters wide and 30 meters long. The soil is so arranged that it resembles a gently sloping roof. Most plots have a ridge at the center which runs the entire length and is about 25 centimeters higher than the soil along the two lower edges. A path $1\frac{1}{2}$ meters wide is made along this ridge. The rows are 8 meters long and run from each side of the path to the lower

sides of the plot. They are 70 centimeters apart, and the plants in the row are 30 centimeters apart.

Controlling the water supply. It is very important that the plants have just the right amount of water, for if either too much or too little be present, the plants will not grow well. To prevent water from standing on the soil near the plot after a hard storm, and also to prevent the roots of near-by trees from growing into the soil with the roots of the betel-leaf plants, a trench 1 meter deep is dug around each plot. The trench should be 1½ meters from the plants. All the plots near Manila are irrigated, as soon as the soil becomes dry, with water that is drawn from wells. An irrigation ditch runs along each side of the path, and the water is run from these ditches along each row.

Cultivating and caring for the plants. A stick about 3 meters long is firmly pushed into the soil near each plant, and as often as necessary the growing stem is tied to it. The sticks in each row are firmly tied to a long bamboo strip that runs the entire length of the row, 2 meters above the soil. Other long sticks, as cross-pieces, are placed 60 centimeters apart and firmly tied to the long strips. Winds are harmful, but the plants can be protected by surrounding the plot with a windbreak of ipil-ipil, cacauate (*Gliricidia sepium*), aroma (*Acacia farnesiana*), bamboos, bananas, or other plants. Large bamboo mats attached to poles or a closely woven fence also may be used to break the wind. The leaves will grow larger and thinner if the vines are properly shaded; either too much or too little shade is objectionable. More shade must be provided during the dry season. New plants are obtained either from cuttings or by layering.[1]

[1] For an explanation of the process of layering, see Book I, page 79.

Manuring the plot. About once a month, fresh, rich soil is scattered between the rows. Once a week, when the row is being watered, a small quantity of manure is added to the soil. Duck, chicken, dove, or goat manure is used. Small fish, oilcake, or other manures or fertilizers that are rich in nitrogen may also be used. Oilcake is usually soaked in a jar of water for two weeks before using, and a small quantity of the mixture is poured into a hole near each plant. The hole is then filled with earth.

Harvesting the leaves. The desirable leaves on each plant are gathered once a week. When the top leaf on a stem is 6 to 8 centimeters long, the second and sometimes the third leaf below is ready to be pinched off. Each week a plant will supply from 5 to 8 leaves. At wholesale prices, from four to fifty good leaves sell for one centavo. In rare instances as many as 100 leaves may be sold for this price.

Varieties of betel-leaf. The betel-leaf (*Piper betle*) has three varieties: the *sanghilo*, the *pula*, and the *kinalabao*. The sanghilo has internodes about 6 centimeters long. It grows rapidly and has large, dark green leaves. To keep the upper part of the vine near enough to the ground to allow the leaves to be gathered, the vine is usually layered three or four times a year.

The pula plants have internodes about 5 centimeters long and large, pale green leaves, which are very tender and more valuable than the dark green leaves of the sanghilo. The pula plants are delicate, the vines grow slowly, and they will not produce large leaves unless fertilized and watered regularly. They are usually layered two or three times a year.

The kinalabao plants have internodes about 8 centimeters long. They grow rapidly, and either with or without culti-

vation produce large, coarse, fibrous leaves. They are layered four or five times a year. They do not produce so many leaves as either of the other varieties and the leaves are less valuable. Usually they are not for sale in the market, except when the pula leaves are very difficult to secure or when the demand for leaves is unusually great.

Betel-nut

The betel-nut is the fruit of the betel-nut palm (*Areca cathecu*). This palm has a long, slender stem and a crown of 6 or 7 dark green leaves. It grows about 15 meters tall. The ripe fruit is orange in color and is about the size of an egg. A fibrous husk surrounds the nut. There are several varieties of betel-nut palms, some of which produce more valuable nuts than others. The betel-nut germinates like a coconut. Plant throughly ripe nuts in a shaded plot and when the shoots are 30 centimeters high, transplant the seedlings to nursery rows or set them in the field. Set them 3 meters apart in soil that is prepared as for coconuts. A betel-nut palm will grow well in any place that would be suitable for a coconut. It will bear in 7 years and when in full bearing yields annually from 100 to 600 fruits. It bears for 30 years or longer. The fruits are gathered the same as coconuts.

Fruits and Vegetables

Fruits and vegetables are healthful as well as agreeable to eat, and they should form an important part of the farmer's diet. An abundant supply of sweet potatoes, yautía, taro, and other vegetables should be grown; and the farmer's family should be able to enjoy oranges, mangoes, bananas,

papayas, chicos, lansones, and other fruits from their own land. Where these plants flourish and a market is near, they may at times be the principal money crop of the farm.[1]

EXERCISES

Exercise 69. To study other farm crops. Collect samples of the different farm crops of the district that have not already been studied. Visit farms where they are grown. Secure information as to the advantages and the difficulties in growing these crops. Study the conditions under which the cultivation of these crops is profitable and consider whether these conditions prevail on the farms from which the pupils come.

[1] See Book I for full information on vegetables and fruits.

CHAPTER XVIII

SILK

THE silk industry has been carried on for centuries in Japan, China, India, and southern Europe. The silk fiber is secured from the silkworm, which is the larva of a large moth. Silkworms feed on mulberry leaves and on the leaves of the castor plant. An abundance of food can be raised for them in the Philippines, and the work of caring for them is suited to women and old or young persons who are not strong enough to work in the fields. It is a great advantage to the Philippine silk producer that he can raise eight or nine generations of worms in a year, while in Japan only two generations can be raised. It is possible, therefore, that silk raising may in time become an important household industry in the Philippines.

Two kinds of silkworms. There are several kinds of silkworms, but only two of these — the mulberry silkworm and the eri silkworm — are of special interest. The Bureau of Science in Manila raises mulberry silkworms in the following manner:

Hatching the eggs. The moth of the female silkworm lays about 300 eggs. The moths are placed on sheets of paper. To keep them from moving about, each moth is placed within a bamboo ring 5 centimeters high. The moths will live for three or four days after the eggs are laid, but they are usually killed as soon as the laying of the eggs is finished. On the sixth day a dark spot appears in each egg; on the seventh day the eggs turn gray; and on the ninth day they hatch. The young worms are about one third of a centimeter long and are dark gray in color. When they are young they are very delicate and must not be touched with the hands.

Caring for the worms. Mulberry leaves are placed over the young silkworms. In a short time the worms crawl up on the leaves. The leaves are then lifted and placed on a

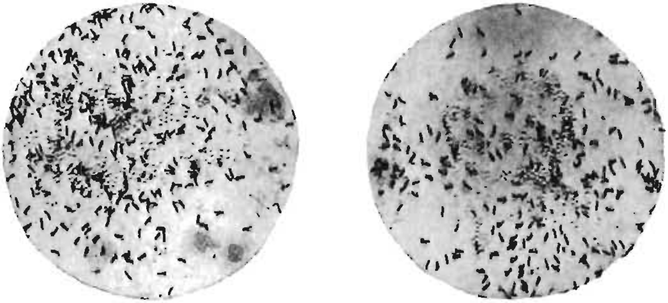


FIG. 132. Newly hatched mulberry silkworms.

tray. When the leaves become dry, a light frame with a coarse abacá-cloth bottom is set over them and on this young mulberry leaves, cut fine, are sprinkled. In a short time the young silkworms will crawl up through the meshes of the cloth and begin eating the leaves. They are then fed several

FIG. 133. Adult mulberry silkworms. The one on the left is a *male*; the other a female.

times a day with chopped mulberry leaves until the third day, when they all go to sleep for a day. After this each silkworm "molts," or crawls out of its old skin. It is then fed on whole leaves for from three to four days, after which it sleeps for another day and molts again. After a silkworm

FIG. 134. Reeling or unwinding silk cocoons. (Exhibit at the First Philippine Exposition.)

has molted four times, it feeds for seven or eight days. It is then ready to spin its *cocoon*. This is a covering of silk that it spins about itself before its last molt.

Spinning the cocoon. Silk is formed from a liquid that comes out of small openings near the mouth of a silkworm. The fine stream of liquid hardens as soon as it is exposed to the air and makes the very slender silk fiber.[1] When a silkworm is ready to spin its cocoon, it is placed in dry cogon grass. As it spins it moves its head from side to side, wrapping thread after thread about itself. The outer layers of the cocoon are made first, and the walls are thickened by adding more fibers on the inside. In about a day the cocoon is complete. The cocoon that contains a male moth is pointed at the ends, while the cocoon about the female is rounded.

[1] Many other insects spin cocoons in the same way. A spider forms its web from liquid which comes from its body.

The silkworm moth. The silkworm sleeps in its cocoon for about eight days. It then molts and comes out of the cocoon, leaving its old skin within the cocoon. The moths are gray in color and have heavy bodies. They have wings but cannot fly. The entire life of the silkworm, from the time the egg is laid until the moth hatches, is from 42 to 46 days.

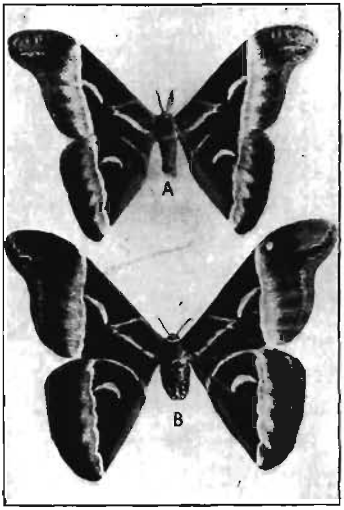


FIG. 135. Adult eri silkworms. *A*, the male; *B*, the female.

Securing the silk. Only enough of the cocoons are allowed to hatch to furnish moths for laying eggs for the next generation. The others are killed by exposing them to hot air. They are then placed in the sun to dry. Each cocoon is like a ball of twine that has been soaked in glue, and a number of them are placed in a basin of warm water to soften the glue-like substance which holds the threads together. Each cocoon contains about 1500 meters of silk fiber, and this fiber can be unrolled like a ball of twine. The fiber is wound on a reel, and is later spun into thread and woven into cloth.

Planting mulberry trees. Any one who wishes to raise mulberry silkworms must first of all plant the mulberry trees that furnish them with food. For information on this subject, address the Philippine College of Agriculture, Los Baños, Laguna.

The eri silkworm. The eri silkworm is a native of India. It feeds on the leaves of the castor plant, and the fibers from its cocoon make a very strong cloth. This silkworm has been raised by the Bureau of Science in Manila, and it seems to thrive in the Philippines.

EXERCISES

Exercise 70. To introduce the silk industry into a community. Write to the Bureau of Agriculture or the Philippine College of Agriculture at Los Baños for information concerning the silkworm and for information as to where mulberry trees may be secured. In case it is considered advisable, set out a few mulberry trees on some farm near the school and get the people there to raise a few silkworms. Later others may become interested.

CHAPTER XIX

CHICKENS

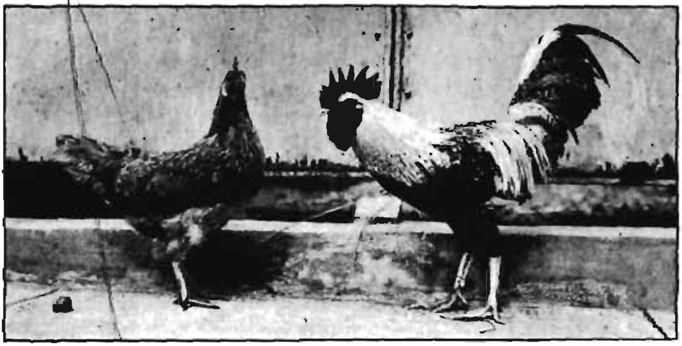


Fig. 136. Philippine hen and cock.

A MODERATE sized flock of chickens on a farm is nearly always profitable. Usually they find a considerable part of their own living, and in doing this they often benefit the farmer by destroying harmful insects. The eggs and the meat of chickens are among the most delicious articles of food that come to the farmer's table, and a very considerable sum may be added to the family income by their sale. Experience is necessary for successful chicken raising, but there are certain principles that every one will find it helpful to understand before taking up this work.

A chicken yard needed. In communities where houses are built close together, chickens that have free range are likely to eat filthy food, drink filthy water, catch various diseases, or get into gardens and destroy plants. In such crowded places it is best to keep the chickens confined in a yard. In

FIG. 137. A home for chicks. The box to the left is for them to sleep in at night.

the lowlands, it may also be better to keep them confined during the rainy season. Even when they can be given free range during certain months, a yard is needed to shut them up in at night and on stormy days. Woven wire 150 centimeters wide and with a 5-centimeter mesh makes a good yard fence. A bamboo fence may also be used.

Laying out the yard. A yard 6 meters wide and 12 meters long is large enough for thirty hens. It should be on sandy or gravelly soil, or on hilly or rolling land that drains well after a storm. In case the soil is damp and muddy, the yard should be drained and then covered with 10 centimeters or more of coarse sand. *The yard should not be damp.* Papaya, orange, or guava trees, together with two or three plants such as violeta, will furnish sufficient shade. The violeta will also serve as a hiding place for the chickens when hawks are

about. Too much shade is bad, and trees that become large should not be planted in the yard.

The care of the yard. Once a year move the yard to new ground. If this is impossible, then at the beginning of the dry season remove the 5 centimeters of topsoil and replace it with fresh, clean, coarse sand. The removed soil may be added to the compost pit or worked into the soil near fruit trees. When the chickens have free range, till the soil in the yard and plant there upland rice, corn, or mungo. Shrubs and tall grass should not be allowed to grow just outside the fence. Keep the space there for a width of 2 meters planted to lawn or to plants like papaya or eggplant. The poultry yard should be a neat and attractive place.

The need for a chicken house. In the dry months chickens may be allowed to roost in trees, but during the rainy season a house is needed to protect them from the wet. When people get wet they can put on dry clothes, but for a chicken this is impossible. If it must go to roost wet, or sit all night in the rain, it will be chilled. Under these conditions it grows little, it does not lay well, and it easily catches diseases.

Building a house. The house shown in Figure 138 is large enough for about thirty chickens. It is 270 centimeters high, 360 centimeters wide, and 255 centimeters from front to back. The posts that support the lower edges of the roof are 90 centimeters above the soil. An open space the width of the door is left through the middle of the house, and five roosts are placed crosswise of the house on each side of this space. The roosts are 90 centimeters from the ground. The back end of the house is closed from the top of the house down to within about 75 centimeters of the ground to protect the chickens from

strong winds and rains. An opening for ventilation is left in each end just under the top of the roof. The front of the house should be away from prevailing storms. On low ground a row of stones 30 to 50 centimeters high should be placed about the house, and the floor raised by filling it in with soil.

FIG. 138. A good chicken house.

A box or ladder should be provided to help the fowls in getting down from the roosts and nests. If this is not done, the feet of the hens may become sore from jumping down on the floor. Ladders should always be provided for hens that roost in trees; for an egg is sometimes broken in a hen that flies and the hen then dies.

The nests. During the dry weather the nests may be placed in shady places in the yard, or wherever it is convenient. In the rainy season they should be in the chicken house. They may be made of boxes or baskets and fastened about the house in convenient places. They should be partially darkened, and a few tobacco stems should be placed in the bottom of each nest to keep away mites. Place dry grass or a rice sack on the tobacco stems to complete the nest.

The care of the house. The droppings from the fowls should be swept up each morning and placed in the compost pit, and a little dry sand scattered below each roost. The roosts should be scrubbed once a month and water that is boiling hot poured over them to kill mites. Or, the roosts may be rubbed each week with a rag wet with kerosene, or new roosts provided once a month. A box of dry road dust should be kept in the

house for the chickens to dust themselves in. On rainy days, feed the chickens in the house where it is dry. They should not go out into the mud and tall wet grass to search for food.

Feeding. Chickens in the wild state live chiefly on seeds, worms, and insects. They also eat considerable amounts of green vegetable matter and fruit and pick up small, sharp stones to help in grinding the food in the gizzard. It will be seen that a chicken eats almost any kind of food, and that in feeding them we should give them vegetable, animal, and mineral matter.

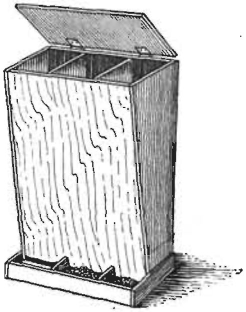


FIG. 139. A box for grit or shells, dry mash, and charcoal.

In the Philippines palay and corn are the cheapest grains. Mungo is excellent for feeding chickens, and vegetables like sweet potatoes, cassava, and squash may also be used. Green feed is always necessary. When the chickens run at large they will pick up enough green food, worms, and insects to supply this part of their food. If they are kept shut up, they should be fed some meat or fish, possibly twice a week. Tender green vegetable matter must be supplied daily. They should also have a supply of crushed shells or coral rock to furnish material for making bones and the shells of eggs. Some poultry raisers have mills in which they grind up fresh bones. This is an excellent food for laying hens.

Feeding for eggs. A hen uses her food to support her body and to make eggs. If the farmer feeds her only enough to keep her alive, he will get no eggs. The most important point

in feeding for eggs is to feed liberally. When they are running at large, hens should have a good feed in the morning and at night all the grain they can eat. Do not allow them to go to bed hungry; for a hen cannot lay eggs unless she is given the food of which they are made. When hens are shut up, they should have a light feeding of grain at noon along with green matter and scraps from the table. On large chicken farms certain foods are kept before the fowls at all times. Only clean food should be given to hens, for dirty and bad-smelling food gives a bad flavor to the eggs.

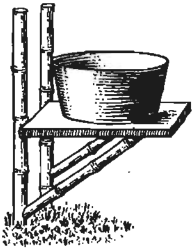


FIG. 140. A device to prevent chickens from scratching dirt into their drinking water. The dish is placed on a shelf 30 centimeters off the ground.

The importance of exercise. Chickens must have exercise to keep them in health. If they are given free range, they will get all the exercise they need. If they are kept in a yard, however, they must be given exercise. Dry grass, rice straw, rice hulls, or other litter should be placed in the yard and the fowls be made to scratch their grain food out of the litter. In the United States the chicken houses have scratch-rooms. The floors are covered with straw, and in wet and cold weather the grain is scattered in this straw. In this way the hens get their exercise without going outdoors.

Water for chickens. Chickens should at all times be able to get clear water. They cannot grow properly and the hens will not lay well unless they have water to drink whenever they are thirsty. The watering dish should be cleaned out daily and kept filled with water of a kind that the poultry keeper himself would be willing to drink.

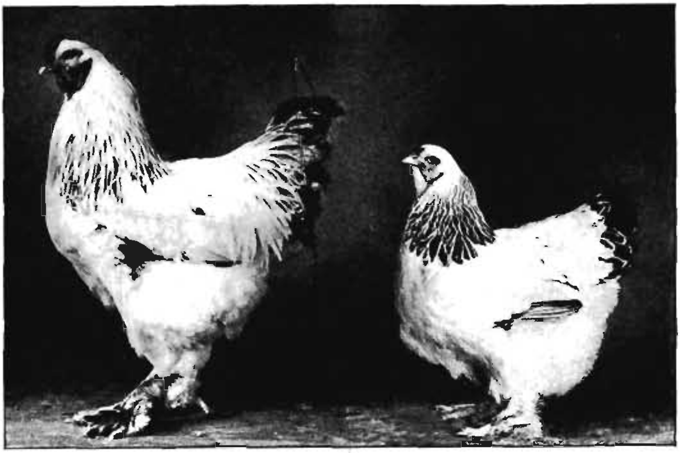


FIG. 141. Brahma cock and hen.

Breeds of chickens. Wild chickens similar to those now found in the forests were caught by man many years ago and taken home and fed and cared for. After a time they became quite tame and when given their liberty did not run away. Man soon noticed that certain of them grew larger than others, and that some hens laid more eggs than others. He also noticed that some were white, black, brown, or gray, and that others were of many colors. By breeding hens with cocks that were alike, man has after many years developed over thirty-two different breeds of chickens. These thirty-two breeds are subdivided into about ninety varieties, but they can all be placed in four classes:

1. *The meat breeds* are the Brahmas, the Langshans, and the Cochins. They are large and are raised for meat. They came originally from Asia and are known as the Asiatic breeds.

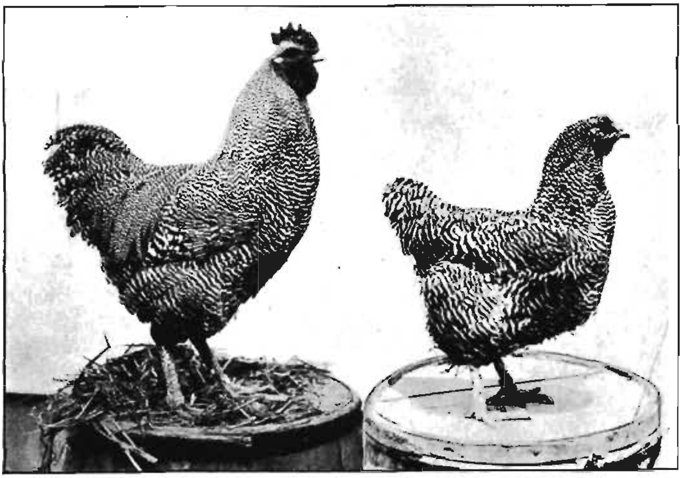


FIG. 142. Barred Plymouth Rock cock and hen.

2. *The egg breeds* lay many eggs but rarely set. They are rather small in size and came originally from the countries bordering on the Mediterranean Sea. The Leghorns, Minorcas, and Spanish fowl are prominent egg breeds.
3. *General-purpose breeds* are good for both eggs and meat. They are of an average size and lay well. The Plymouth Rocks, Wyandottes, and Rhode Island Reds are the most popular of these breeds. They have been bred in America by combining other breeds. The Cantonese, or Chinese fowl, is raised around Manila as another general-purpose fowl. It is a short-legged bird with fluffy brown feathers.
4. *The miscellaneous breeds* include the Bantams, Game, and Crested breeds. They are known respectively for their small size, their ability to fight, and their elaborate plumage.

The best breed for the Philippines. For the Philippine farmer, it is probable that a general-purpose breed or an egg-laying breed is better than one of the heavy meat breeds. Where they can be given free range, the active egg-laying breeds do well. Where they must be shut up in small yards, the more quiet general-purpose fowls are better. When the chickens are kept chiefly for eggs, the White Leghorns are the most popular breed. If they are being raised chiefly for their meat, a heavier breed will be selected. In most cases the Philippine farmer should first raise the native chickens until he understands how to care for them properly. He may then secure a cock of an improved breed and cross it with his hens. Later, if he wishes to do so, he may secure some pure-bred hens and use them for breeding purposes. It is best to keep only one breed.

Strain more important than breed. In all breeds of chickens there are some strains or families that are good layers and others that are poor layers; there are some strains that are so

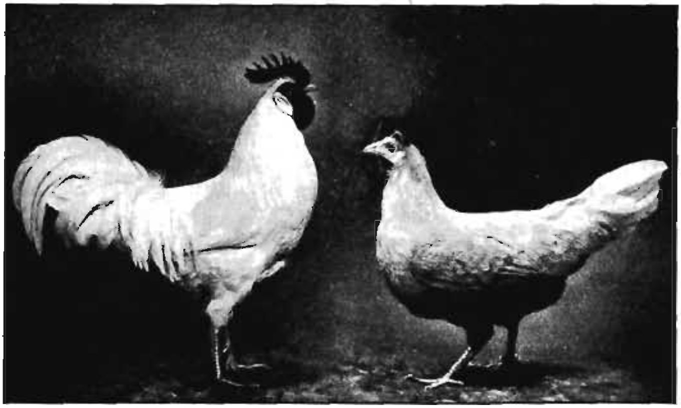


FIG. 143. White Leghorn cock and hen.

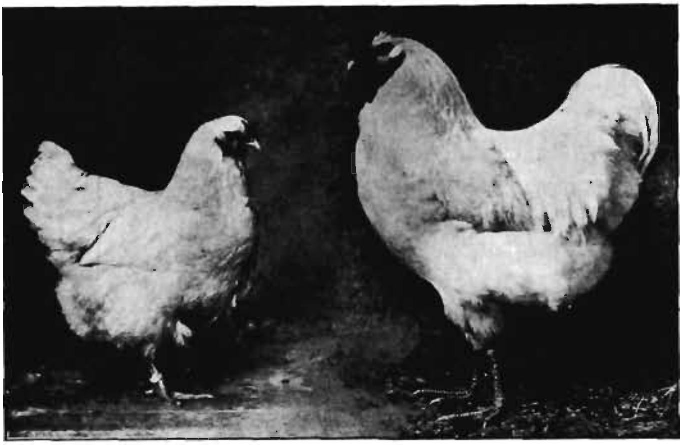


FIG. 144. White Wyandotte hen and cock.

hardy that the chicks are raised without difficulty, and others so delicate that it is almost impossible to keep the chicks alive. It is not so important, therefore, to keep any particular breed as it is to have a good strain of that breed.

The native Philippine hens begin to lay when they are about ten months old and lay from 60 to 80 eggs their first laying year. This average can be greatly raised; for in the United States the pullets of the egg breeds begin laying at five or six months, and even with the cold winters the best flocks lay on an average from 150 to 175 eggs in a year. One hen laid 314 eggs in a year, and there are many hens that lay from 200 to 250 eggs in a year. The entire flock of which Lady MacDuff (Fig. 146) was a member averaged 212 eggs for a year, and flock averages even better than this have been reported.

Breeding good layers. Many hens, even with the best of care, lay only a few eggs. Other hens lay a large number of eggs. The poultryman should know which of his hens are the

FIG. 145. Lady Eglantine, the world's champion hen. Her record is 314 eggs in a year. She is a White Leghorn.

FIG. 146. Lady MacDuff, a former world's champion. She laid 303 eggs in one year, and 512 eggs in two years.

best layers, and at hatching time he should set only the eggs from these hens. In breeding for eggs it is especially important that a cock from a good laying hen be used.

Selecting hatching eggs. Eggs that are used for hatching should be well shaped, they should be clean, and they should be from hens and not from pullets.[1] If possible, select eggs from hens that have never been diseased; for it is believed that chicks from the eggs of hens that have been sick are weak. Until the eggs are set they should be kept in a cool place and turned over each day.

Hatching the eggs. Eggs are usually hatched by placing them under a hen. A good nest for a setting hen may be made in a box or basket about 30 centimeters deep. Fill it

[1] A *pullet* is a female chicken under one year of age. A young cock is called a *cockerel*. A little chicken is called a *chick*.

half full of moist soil and then cover the soil with a clean rice sack or with fine dry grass. Make the nest slightly higher at the edges, so that the eggs will not get out from under the hen and become chilled. It is a good plan to sprinkle some tobacco dust in the nest, or place some tobacco stems on the soil, to drive away mites. Place the nest in a quiet place and keep water and an abundance of food where the hen can get them. In about 21 days the chicks will hatch.[1]

FIG. 147. *This hen laid no eggs for a whole year. It is not safe to judge by appearance alone, for she is apparently a first-class White Leghorn hen.*

Testing the eggs. After the eggs have been under the hen a week, they may be tested to see if the chicks are growing in them. This may be done in the following manner:

Set a lamp or candle in a kerosene can. Mark on the side of the can the height of the flame of the lamp or candle. Then cut a round or oblong hole in the side of the can about 3 centimeters in diameter. Test the eggs at night by placing a light inside the can and holding the eggs against the hole.[2] The chicks can be clearly seen as dark objects in the eggs. Eggs that are clear have no chicks in them and will not hatch.

[1] The hatching periods of different kinds of eggs are as follows: Hen, 19 to 24 days; turkey, 26 to 30 days; guinea fowl, 25 to 26 days; pea fowl, 28 to 30 days; duck, 25 to 32 days; goose, 29 to 32 days.

[2] A very satisfactory egg tester can be made by cutting a hole in a sheet of cardboard and holding it in front of a lamp. A rather large sheet that will shade the eyes from the light is best.

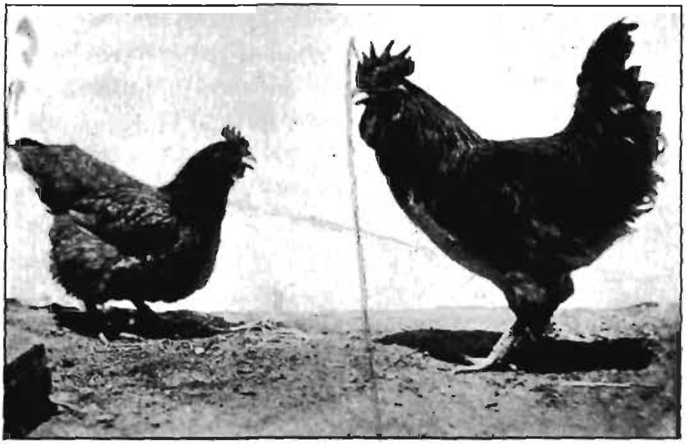


FIG. 148. Cantonese hen and cock. A flock of hens of this breed kept at the Santa Maria Farm School, Ilocos Sur, averaged 182 eggs each in a year.

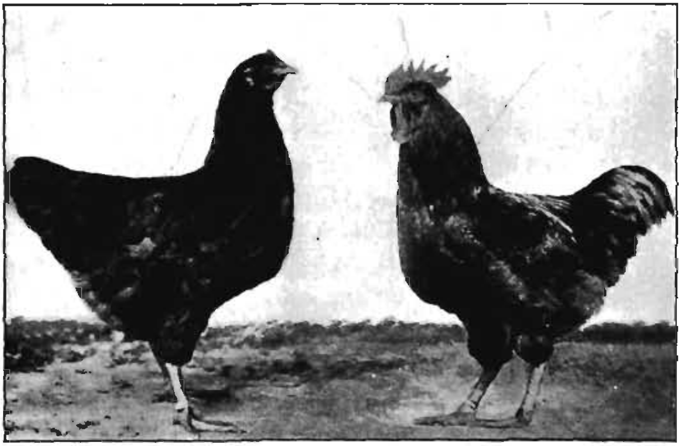


FIG. 149. Rhode Island Red hen and cock. This is a good general-purpose American breed. The hens are good layers and make excellent mothers for the little chicks.

Keep the eggs covered while they are being tested, and put them back under the hen before they become chilled. Remove from the nest all eggs that do not have chicks in them; for if this is not done, they will decay and give off poisonous gases that will injure the chicks in the other eggs.

FIG. 150. A small hot-water incubator. Capacity, 60 hen's eggs. It will hatch hen, duck, or turkey eggs.

Hatching with an incubator. Where chickens are hatched in any considerable numbers, incubators are used. It is not difficult to care for an incubator, and the chicks that are hatched in it are free from lice and disease. A small incubator will hold 60 eggs, and larger ones hold up to several thousand.

Raising chicks without a hen. When chicks are hatched in an incubator, they are raised without a hen. Some persons set several hens at once and raise all the chicks together in a coop without a hen. A good coop for this purpose is shown in Figure 137. It is 2 meters long, 1 meter wide, and 55 centimeters high on the sides. It has a wooden frame and is covered on four sides with wire netting that has a 2-centimeter mesh. Bamboo slats or woven bamboo strips may be used instead of the woven wire. The roof is made of grass. Place the coop on loose soil that is well drained and recently tilled. If the soil is clay, work in with it a quantity of coarse sand to make it loose so that the chicks can scratch in it. Move the coop to a new place every few days.

Each evening place in the coop a box like the one shown in Figure 137, for the chicks to sleep in. When the chicks are small or when the nights are cold, the lid of the box should be closed. Openings must be made for ventilation, or the lid of the box must not be closed tight. The chicks should be let out about seven o'clock each morning, and the box removed, cleaned, and placed in the sunshine until evening.

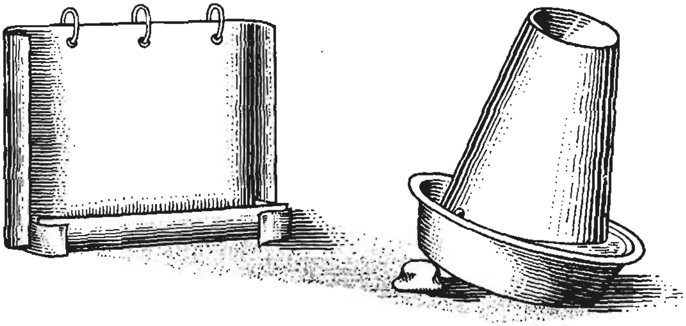


FIG. 151. *To the left, a bent tin to hold chicken feed. To the right, a can and dish for water for chicks and ducklings.*

Raising chicks with a hen. A hen often takes small chicks out into the wet grass and weeds, and leads them so far from the house that they are caught by hawks and other enemies. It is best, therefore, to keep the hen in a small coop. This may have an opening in it that will allow the chicks to pass out and run about outside the coop. The coop should be moved to new ground frequently.

Feeding the chicks. Baby chicks should have water from the time they are hatched, but they should not be fed until they are 48 hours old. Then they should be given a mixture of finely chopped hard-boiled egg and toasted bread crumbs six times a day. In a few days cracked rice, cracked mungo,

or millet seed may be fed. At all times grit should be kept before them, and an abundance of tender green vegetable

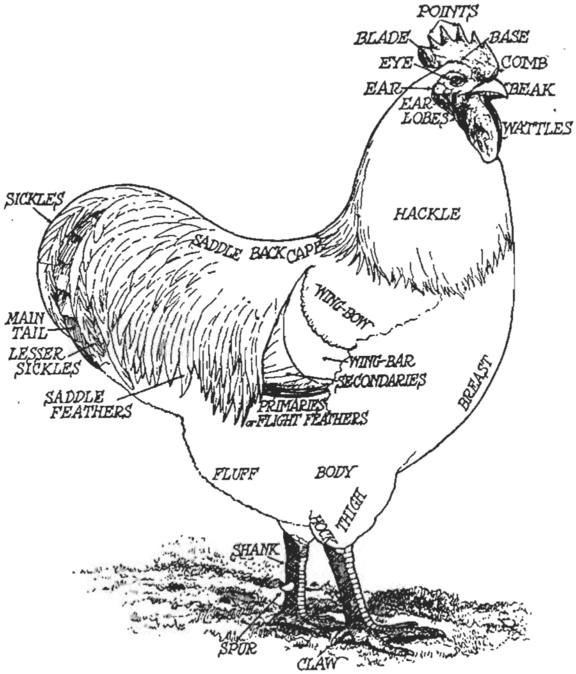


FIG. 152. Cock marked to show parts.

matter should be furnished. Sprouted mungo seeds or lettuce leaves are good.[1] By the second week four feedings a day and later three feedings a day are sufficient. If the chicks are not running out where they can catch insects and worms, they should occasionally have some chopped meat or small fish.

A flat piece of tin 5 centimeters wide, about 30 centimeters long, and turned up along one side, as shown in Figure 151, may

[1] See Book I, page 121, for directions for sprouting mungo seed.

be fastened to the side of the coop to hold food for the chicks. A device for holding water is shown in Figure 151. The open end of the long can has a hole a short distance from the rim. Fill the can with water, place the dish over the top, and invert the two together. A small quantity of water will run out into the dish. Change the water several times a day.

FIG. 153. Instruments for caponizing.

Selling surplus stock. Usually a farmer should hatch out more chickens than he needs. The vigorous, healthy pullets that grow fastest will be the best layers. These he should keep, and the others he should sell or use for food. He should keep a few of the best cockerels for breeding purposes, and either sell the others while they are small or caponize them. Capons grow very large, and sometimes it is profitable to raise them for meat. The farmer should not keep a large flock of young cockerels, for they eat a great deal of valuable food. Hens lay best during their first laying year, and it is usually more profitable to sell hens when they reach the age of two years and raise others to take their place.

Breaking a broody hen. When a hen commences to sit, she should be taken off the nest *at once* and put into a coop. This coop should be raised from the ground and should have cracks in the bottom; for if a hen's breast is cooled, she will lose her desire to sit. While the hen is in the coop she should be watered and well fed, so that she will be ready to lay again in a few days.

Diseases of Poultry

The three common diseases of poultry in the Philippines are gapes, roup, and tuberculosis. All of these diseases are infectious. That is, one chicken catches them from another as one person catches cholera from another, or as one carabao gets rinderpest from another. The way to keep chickens from having these diseases, therefore, is to keep them away from other chickens that are sick with them. The farmer should always take the greatest care in bringing new chickens on his place; for they may bring with them disease that will destroy his whole flock.

Roup. Roup is a cold in the head. The eyes and nose run with foul-smelling matter. The head swells, and the bird sometimes becomes blind. This disease is caused by a micro-organism. It is catching, and chickens sick with the roup should be immediately separated from healthy ones. If possible, remove the healthy chickens to a new house and yard. If this cannot be done, disinfect the coop and yard with carbolic acid and water or with some other disinfectant. In using carbolic acid, mix one part of the acid with twenty parts of the water.

Roup is a very infectious disease and a bird that is sick with it should be killed at once and its body burned or buried deep in the ground.[1] A fowl that has had roup may carry the germs for a year or more after it seems to be well, and it is

[1] If an attempt is made to save a chicken sick with roup, bathe its head and throat in a basin of warm water to which a small spoonful of salt has been added. Wash well about the eyes and nose to loosen the waste matter. Afterwards put its head into a dish containing a 2 per cent solution of permanganate of potash and hold it there for half a minute. The lining membrane of the nostrils and mouth is then thoroughly bathed in the solution. The sick

very difficult to free a flock from this disease. It is usually best, therefore, when it attacks a flock, for the farmer to sell all his chickens and keep no fowl on his place for two months.

FIG. 154. A chicken sick with the roup.

Then he can buy healthy hens and start again with a healthy flock. One reason for using great care in bringing strange birds on a farm is that these may have had roup and may still be carrying the germs of the disease.

Roup is especially severe in flocks that are kept in damp, cold houses and yards. For this reason the floor of the house should be dry, the yard well drained, and sunshine abundant where the fowls live. When the disease breaks out in a flock, enough potassium permanganate should be added to the drinking water to give it a light red color. This kills the germs that are left in the water by the sick birds. The effective

fowl may also be given Epsom salts. Dissolve $\frac{1}{3}$ of a teaspoonful of the salts in a little water mixed with rice bran and give it through a tube. Keep the bird in a dry place out of the wind, and feed cooked rice and pepper or ginger.

way of preventing this disease, however, is to keep all sick birds away from the flock. In towns and villages it may be necessary to build chicken yards to keep the fowls from getting roup from neighboring flocks. A person who has been handling a sick fowl should wash his hands in carbolic acid or some other disinfectant before he goes about the well birds.

Gapes. Gapes is caused by small red worms in the windpipe. A bird with this disease gapes, frequently shakes its head, coughs and sneezes, and discharges mucus and worms. It usually stands by itself, all humped up, with eyes closed and from time to time gapes or opens its mouth very wide. The worms attach themselves to the lining of the windpipe and suck the blood. If many of them are present, a fowl may die from loss of blood or from lack of air. This disease is most dangerous to chicks from one to four weeks old. An old hen may have a few of the worms in her windpipe and appear perfectly healthy, but chicks running with her may eat worm-eggs and worms coughed up by her. A chick may also eat worms and eggs coughed up by another chick. Worm-eggs are also found in the droppings from infected fowls. The eggs of the worm live for months in the soil; they are often found in earthworms; and chicks may contract the disease by eating earthworms that live in infected earth.

Preventing gapes. When this disease breaks out in a flock, remove the sick birds and move the healthy ones to new ground. Wash the drinking dish clean and then scald it with boiling hot water. Shut the fowls in a coop and each day carefully watch for infected birds. Whenever one of these is found, remove it and move the coop to fresh ground. If possible, change the poultry yard and plow up and cultivate the old yard and plant there some crop. If the chickens must be

kept in the same coop or house, this should be disinfected.[1] The eggs of the gapeworm and the earthworms that carry these eggs may be killed in the earth by pouring strong brine on the ground.

Treatment for gapes. The only treatment that can be given is to kill the worms in the windpipe. Take a feather and strip it all but the tip. Dip it in olive oil and, with a twisting motion, push it down the bird's windpipe. The idea is to cover the worms with oil wherever they happen to be attached. The oil kills them and they are then coughed up. Some poultrymen use turpentine or kerosene instead of olive oil. Burn the worms removed.

Tuberculosis. Tuberculosis is caused by a germ, and one fowl gets this disease from another that is sick with it. An infected fowl becomes thin and its comb is pale. Usually it has a diarrhea. Its legs and feet appear swollen. The only treatment is to kill and burn every infected bird. Sunshine, pure air, plenty of exercise, and good, wholesome food help to prevent the disease, but usually it destroys the entire flock.

Chicken pox. A very common disease among poultry is chicken pox. The chickens infected with this disease break out in small sores around the eyes and nose. Often one side of the head is a mass of sores. Very frequently the fowl becomes blind in one eye. Chickens get the disease from other chickens that are suffering from it.

A good treatment for chicken pox is to wash the head several times daily in a 2 per cent solution of permanganate of potash. This disease can be cured, but it is much better

[1] The following disinfectants are good: permanganate of potassium and water; bichlorid of mercury or carbolic acid and water. Sprinkle the walls of the coop, the nests, the roosts, and the floor with one of these solutions.

to prevent it. Do not allow a fowl with the disease to be brought on the farm.

The best way to treat a sick fowl. Any fowl that has been cured of an infectious or catching disease is much less valuable than a similar fowl that has never had the disease. In general the best way to treat a fowl sick with an infectious disease, is to wring its neck and bury it.

Lice and mites. Lice are small animals that are often found on fowls. They live by feeding on the skin and often cause the fowls great annoyance. Mites live in the houses and nests. Some kinds of them suck the blood from the fowls at night or when they come on the nest. Others feed on the feathers and on the skin at the base of the feathers, sometimes loosening the feathers and causing them to drop off. Mites must be killed by treating the roosts and house with hot water or kerosene (page 208). Very fine lime scattered about the house helps to hold them in check. They may be driven away from nests with tobacco stems or tobacco dust (page 172).

Lice are best prevented by providing boxes of fine dust for the fowls. When the fowls wallow in this, the lice are smothered and killed by the dust. Tobacco dust added to the earth in the boxes will kill the lice much more quickly. If lice are present in great numbers, the fowls should be treated with insect powder. Hold a fowl by the legs and shake the powder down among the feathers. Then with the hand work the powder down to the skin, where it kills the lice. A setting hen should be treated with insect powder when the eggs are put under her, and again two or three days before the chicks hatch.

The advantage of using incubators. One great advantage in using incubators is that the chicks hatch free from lice,

gapeworms, and the germs of roup and tuberculosis. If they are kept in clean coops and away from other chickens, they will remain free from all these diseases. The farmer ought to have his place free from disease and keep it free, and an incubator helps him very greatly in doing this. If his chickens have been dying with roup, gapes, or tuberculosis, he should sell them all and start again with a healthy flock. One of the best ways of doing this is to secure eggs from a good flock, and hatch them in an incubator. A small incubator is large enough for the average farmer.

EXERCISES

Exercise 71. To make a study of chicken raising in the community. Visit various farms where chickens are kept and observe the methods of housing and feeding, the prevalence of disease, the number of fowls kept, and other points connected with the industry. Discuss with the class the difficulties in raising chickens and whether it is possible to overcome these.

CHAPTER XX

OTHER POULTRY

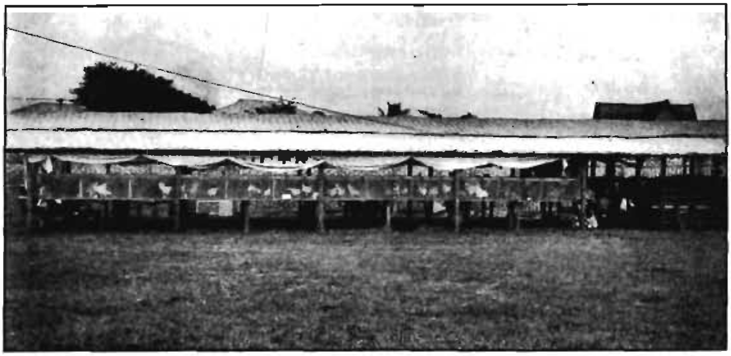


FIG. 155. Poultry exhibit at the First Philippine Exposition.

THE word *poultry* includes chickens, ducks, geese, turkeys, guinea fowl, and pigeons. Of all these, chickens are the most commonly raised in the Philippines, but on some farms other kinds of poultry may be even more profitable. With a good place to keep fowls and a market conveniently near, a handsome profit can be made by raising poultry of almost any kind.

Ducks

In Java, where the Malays are practically all Mohammedans and consequently do not eat pork, thousands of ducks are raised. It is a very common sight to see in the fields hundreds of flocks of ducks, each flock herded by an elderly person who takes the ducks out in the morning and brings them in again at night. Great numbers of ducks are raised in China

also, and in certain towns near Manila many of them are kept. They could be kept profitably in many other places in the Philippines, for they are not troubled with lice and mites, they do not suffer from the diseases that attack chickens, and their eggs and meat are excellent food. They eat more than chickens, but they will gather a portion of their food in near-by fields, and, except in towns where the houses are very close together, each household can profitably keep a few ducks. They may be raised without water for them to swim in.

Hatching duck eggs. Duck eggs can be hatched under hens in the same manner as hen's eggs. The only difference is that the hatching period is longer. Ducks are seldom allowed to hatch their own eggs. When young ducks are to be hatched in large numbers, incubators may be used. The incubator shown on this page will hatch duck eggs very successfully, and in the provinces near Manila, where great num-

FIG. 156. Incubator for hatching duck eggs. The cloths on the floor contain either eggs or palay.

bers of ducks are raised, the eggs are hatched in incubator houses.

Use of incubators. Long bins of rice hulls, 80 centimeters wide and 70 centimeters high, are placed on the ground, either under a house or in a separate building. Baskets about 50 centimeters in diameter and 70 centimeters deep are set in these bins, the rice hulls being packed closely about them. The baskets are placed about 10 centimeters apart. In pieces of abacá cloth 85 centimeters square are placed the duck eggs; about 120 eggs are put in each piece of cloth. In other squares of cloth about 3 liters of palay are placed. Before the palay is put in the cloth, it is placed in a heated iron kettle and stirred with the hand for from 20 to 50 seconds. Each basket in the incubator is then filled as follows: one cloth with its heated palay is spread over the bottom of the basket, and on this one cloth of eggs is spread; another cloth of warm palay is added and then another cloth of eggs. The basket is filled in this way with warm palay and eggs, and a rice sack is thrown over the top of the basket to keep in the heat.

For the first twelve days the eggs and palay are taken out of the baskets twice daily. The palay is freshly heated, the eggs are turned over, and then they are again placed in the baskets. After the twelfth day the palay is no longer used. The eggs are taken out of the baskets three or four times daily, turned over, left to air and cool for two or three hours, and then again returned to the baskets. As the ducklings grow in the eggs they produce more and more heat, and after the twelfth day it is not necessary to use the warm palay. From this time until the eggs hatch, the greatest care must be taken to keep them from becoming too warm.

After the eggs have been incubated for 20 days, they are

FIG. 157. An incubator for hatching duck eggs. The eggs are turned over from time to time. The cloth behind the table keeps off draughts.

placed on a table as shown in Figure 157. This table is covered 8 centimeters deep with rice hulls, over which a mat is spread. The eggs are placed on this mat and are covered with a large, coarse cotton cloth, over which is placed another mat. To keep the wind from blowing on the eggs, a cotton cloth is hung about the table as a mosquito netting is hung over a bed. The eggs are turned every two hours and when about to hatch, every hour. When the ducklings make a noise within the eggs, the top mat is removed. When a few of them are out of their shells, the cloth is rolled back and the hatched ducklings are placed in a shallow basket that has dry straw in the bottom. The empty shells are removed from the table, the unhatched eggs are turned over and placed close together, and the cloth is again spread over them. When more ducklings are out, they are removed in a similar manner until the hatch is complete. Then the shells and unhatched eggs are removed and the table made ready for another hatch.

FIG. 158. Ducks in an inclosure along a river bank.

The care of the ducklings. The ducklings must be protected from dampness, wind, rain, lizards, and rats. The floor where the ducklings run should be covered with dry straw or with a mat. They should not be fed for the first 36 hours, for during this time they are living on the yolks of the eggs, which were absorbed before hatching. For the first 15 days they should be fed every two or three hours with cooked rice that has been dipped in clean water. Later they may be fed cooked palay for 10 days and after that palay and river snails. In feeding scatter the rice on the mat and give them only as much as they will eat quickly. After the eighth day give them a few small crayfish or shrimps. After the twelfth day give them water in a vessel 5 centimeters deep; the water in the dish should be 4 centimeters deep. *Do not allow the ducklings to get wet.* Give them a drink three times a day, and when they are one month old allow them to swim 10 minutes daily in fresh running water. Later they may be allowed to remain in the water a longer time, and after they

are two months old they should be allowed the free use of the water, as shown in Figure 158.

A sleeping house necessary. At night ducks should be kept in a building with a dry floor. Scatter rice hulls on the floor to make it soft, and from time to time replace these rice hulls with fresh ones. The old hulls that are mixed with the duck manure are excellent fertilizer. The soil about the building should be well drained. For breeding purposes ten ducks should be placed with one drake.[1]

Different breeds of ducks. There are many different breeds of ducks. Some breeds are large and are raised chiefly for their meat; some are small and are valuable for the eggs they produce; others are general-purpose breeds and are kept for both eggs and meat. In the United States the Pekin duck (a large white duck from China) is the most popular meat breed, and the Indian Runner duck (which probably came from Belgium and near-by countries) is the best of the egg-laying breeds. Other popular breeds are the Rouen duck from France and the Aylesbury duck from England. Several other breeds also are raised. Whether or not foreign breeds of ducks would be better suited to the Philippines than those now raised here is not known, but some of them have been carefully bred for many generations and the duck raisers of the Philippines might find them valuable.

Geese

The female goose is usually permitted to hatch her own eggs, but they may be hatched under hens or in incubators. The goslings (young geese) should be given the same protection as ducklings, and for the first month or so may be given

[1] A male duck is called a *drake*.

the same food. They should be provided with clean water, *clean food, and a warm, dry place to sleep. None of them* need food for the first 36 hours. Besides the other food, they should be given tender green vegetable matter chopped fine. Feed them the same as ducklings, but do not give them too much. Keep them a little hungry all the time. Crushed sea-shells, crushed rock, and fine charcoal should always be kept near.

Turkeys

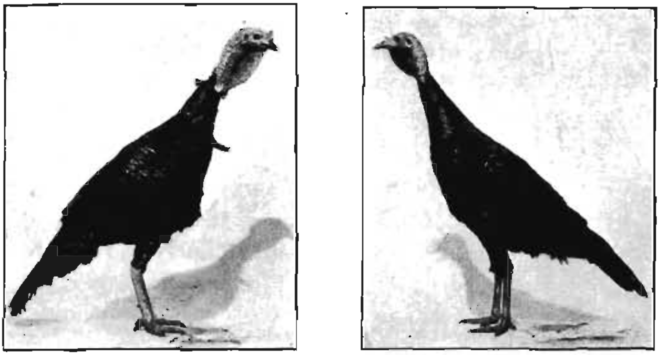


FIG. 159. A turkey cock and hen.

Sometimes the female turkey is permitted to hatch her own eggs. Turkey eggs may also be hatched under hens. The young turkeys may be fed on egg mixed with cooked rice and sprinkled with a little sharp sand. The egg may be either raw or boiled for thirty minutes. For the first two weeks feed them every three hours and after that three times a day. Give them cracked rice, millet, and corn, and plenty of tender green vegetable matter. From time to time let them run out on the grass, but do not let them get wet. After a month or so allow them to run at will to gather insects and other food.

Turkeys are good walkers and will find a larger portion of their food than chickens. Gravelly or rocky highlands that are well drained are the best places to raise turkeys, while wet, muddy lowlands are the worst. Each household that is suitably located should keep a few turkeys. They do well when allowed to roost in trees.

FIG. 160. A neat, attractive home for pigeons.

Pigeons

One poultryman who has a good flock of chickens and also has about thirty pigeons, states that when work and feed are considered his pigeons are more profitable than his chickens. The pigeons are fed grain every evening and their house is cleaned out and disinfected once a week. He gathers three or four squabs (young pigeons) each week. A clean house, plenty of food, and protection are all the care given them.

Guinea Fowl

Guinea fowl were first domesticated in western Africa. However, they are now found in nearly all parts of the world. Guinea eggs and the meat of the young fowls are excellent food. Guineas require a good range and trees in which to roost. They are light sleepers and quickly make a noise if disturbed at night. They do best in districts that have a pronounced dry season.

Opportunities for poultry raising in the Philippines. During 1913 there were imported into the Philippines from China 54,619,360 eggs, which were valued at ₱716,184. The same year chicken, duck, and turkey meat valued at ₱23,276 was imported from Australia. At all times there is a great demand for poultry and eggs in the Manila market, and high prices are paid for them.[1] There is therefore a great opportunity for poultry raising, especially chicken and duck raising, in the Philippine Islands. To succeed in this industry the Filipino farmers must give attention to the following points:

1. They must shelter their fowls from wet and cold, and learn how to raise the young without great loss.
2. They must give more attention to breeding.
3. They must learn how to feed their fowls for eggs and for growth.
4. They must learn to keep them free from disease. Just as rinderpest and surra must be controlled before it is profitable to try to raise cattle and carabao, so the dis-

[1] The following were the prices in the Manila market in August, 1914:

Live chicken	₱ .30 to .80 each
Live capon	2.00 to 3.00 each
Live turkey	1.50 to 7.00 each
Live duck	.60 to 2.50 each
Live goose	2.00 to 3.00 each
Live squab	.30 to .50 each
Hen eggs, fresh	.50 to 1.00 a doz.
Hen eggs, imported	3.00 a hundred
Duck eggs	3.00 a hundred
Cold storage poultry:	
Turkey, per kilo	1.70
Goose, per kilo	1.35
Duck, per kilo	1.35
Chicken, per kilo	1.50
Capon, per kilo	1.50

eases of poultry must be controlled before the poultry industry can flourish.

Good housing, good breeding, good feeding, and good sanitation will make poultry raising a success.

EXERCISES

Exercise 72. To study the kind of poultry that may profitably be raised in a community. Visit the farms of the district and learn what kinds of poultry are kept. Find out the prices received for poultry and eggs. Remember that low, wet localities are best suited to ducks and dry, hilly regions to turkeys. Make a study of the food supply that would be available for different kinds of poultry. What kinds might be profitably raised?

CHAPTER XXI

PREVENTING LOSSES ON THE FARM

It is by work that the farmer's crops are grown. It is by work that the farmhouse and other buildings are placed on the land. It is by work that the farmer earns the money that buys the other things that are used on the farm. *Everything that the farmer gets comes by work; all wealth is created by labor.*

When a good house burns, the work that went into the building of the house is lost. When a valuable carabao dies, some one must do enough work to pay for another one. Whenever anything of value is lost or destroyed on a farm, more work must be done to replace it. The farmer, therefore, must protect himself as much as possible from the loss of his buildings, his animals, and his crops; for when these are lost his labor is lost; he becomes poor because the wages that he received for his work are gone.

Destructive agencies. The agencies which destroy the building, the animals, and the crops of the farmer may be divided into three classes:

1. Destructive forces of nature — baguios, floods, drought, and fire.
2. Diseases — fungi (singular, fungus)[1] and microörganisms that attack plants and animals.
3. Destructive animals — insects, rats, hogs, and monkeys.

Some of these agencies we have already discussed. Others of them we shall consider in this chapter.

[1] Fungi are plants that have no green coloring matter. Mushrooms and molds are good examples of fungi.

Baguios. During and between the months of June and October strong windstorms called *baguios* often pass over different parts of the Islands, destroying crops and buildings and often killing people and animals. There is no way to prevent these storms, but the farmer can in part escape the losses that come from them. This he can do by planting crops that the baguios do not seriously injure; by raising a number of crops so that there will be a harvest every three or four months; and by making the buildings and fences on the farm so strong that they will not be destroyed.

If possible, the farmer should make his buildings of a kind that will stand for years. One great difficulty in the way of progress and prosperity in the Philippines is that most of the buildings are of a kind that last only a few years; hence the people must spend much of their time and money in building new ones. Whenever possible the farmer should build a house that will serve as a home for his family for years and as a home for his son after him. Such a building will withstand the storms and will need to be rebuilt only once in many years. A farm community with permanent buildings is on the road to permanent prosperity.

Fire. During the dry season fire sometimes causes considerable damage to cultivated crops. High grass growing among young coconut trees often gets on fire and kills the young trees. For this reason the soil between the trees should be tilled frequently and planted with some profitable crop. Grass should never be allowed to grow among the trees.

In locating his buildings, the farmer should place them far enough from each other so that they will not all be destroyed if one is burned. Rows of cooking bananas planted between buildings are a great protection against the spread of

fire.[1] The farmer should see that his stove is safe and should be careful about the lamps and matches that are used in his home.

Diseases of plants.[2] Many plant diseases are caused by small, threadlike *fungi*. They grow in the stems, roots, leaves,

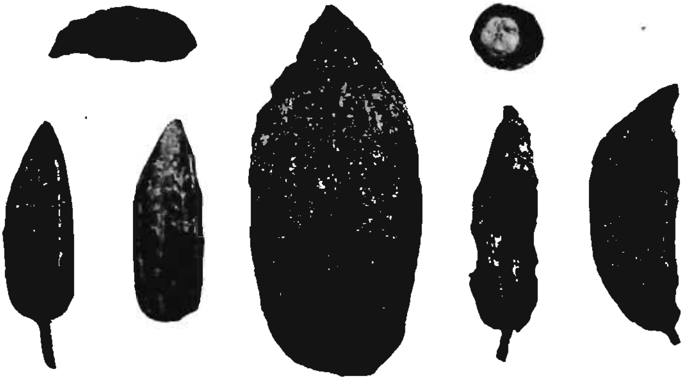


FIG. 161. Cacao fruits affected by the fungus that causes the disease known as black-rot.

and other parts of plants, and at fruiting time produce small bodies that are called *spores*. The spores are carried from one plant to another by wind, by insects, and by people, and when they reach a new plant that they like they germinate and grow into the new plant. The plant is then said to be diseased.

There are thousands of species of fungi, and almost every crop plant has certain of them that grow in it. One of the most destructive is the coffee rust.[3] Other diseases

[1] In one town where 30 stores and 75 houses were burned, the fire was finally stopped on every street where houses were protected by these banana plants.

[2] Diseases of animals are treated in Book III. [3] See Book III, page 25.

caused by fungi are: stem disease of cacao; damping-off disease of tobacco seedlings; root disease of rubber; corn smut; tomato wilt; rice smut; black rot of cacao; canker of cacao; and root disease and red disease of sugarcane.[1]

FIG. 162. White heads of rice, due to stem-borers.

Control of fungous diseases. The following methods are used in controlling fungous diseases:

Cutting out and burning all infected plants. In Java the coffee rust is controlled by cutting down and burning all the diseased plants, and where a disease is not widespread this is the best method of keeping it in check. In this way the coconut bud-rot in Laguna was controlled.

Spraying. In Europe and the United States certain fungous diseases are kept in check by spraying the leaves with substances that will kill the germinating spores of the fungi. For this purpose Bordeaux mixture [2] is generally used. It is

[1] Certain diseases of plants are caused by microörganisms, such as bud-rot in coconuts (page 125).

[2] At Bordeaux, France, it was customary in certain vineyards to sprinkle a few rows of grapevines near the road with a mixture of lime and copper sulfate to give them a poisonous appearance to ward off depredations of the hungry passers-by. The vines so treated were noted to be less injured by downy mildew (a very destructive fungous disease) than were vines not treated. Since then Bordeaux mixture has been used to spray many different kinds of plants to prevent them from becoming infected with fungous diseases.

made as follows: Dissolve 300 grams of copper sulfate in half a kerosene can of water. Then mix 300 grams of unslaked lime with a small amount of water till the lime has absorbed all the water that it will take and the mixture is like thin sirup. Then add half a kerosene can of water. When ready to use, pour into a third vessel equal quantities of the copper sulfate solution and the limewater mixture, *stirring vigorously all the time.* The lime may be mixed up in a tin or iron vessel, but a wooden or earthenware vessel must be used for the copper sulfate solution and for the mixture of the two solutions. The two solutions will keep as long as they are separate, but they should be used as soon as possible after they are mixed.

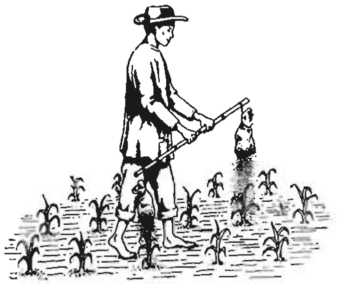


FIG. 163. Putting poison on corn leaves.

Bordeaux mixture prevents plant diseases by killing the germinating spores of the fungi. It can best be applied with a spray pump, but when only a few plants are to be sprayed it may be shaken on with a small broom. At the beginning of the rainy season it is often sprayed on such trees as coffee, orange, and cacao. Before a plant is sprayed, all infected leaves and stems should be removed and burned. Heavy rains wash the mixture from the leaves and make another application necessary.

Protecting wounds in trees. The rotting of the wood in trees is caused by fungi that enter through wounds. When a branch is cut from a tree, the wound should be covered with paint or tar. A branch should always be cut off close to the

stem that supports it so that the wound will heal over. Unless it is painted, the dead end of a cut limb may allow fungi to grow into the heart of the tree.

The use of fire on tobacco beds. A fungus that lives in the soil attacks tobacco seedlings and causes their stems to rot. This fungus can be destroyed by covering the earth where the seeds are to be planted with dry vegetable matter and burning it. The heat kills the fungus in the soil and the seedlings that grow later will be free from the disease.

Breeding disease-resistant plants. Often a plant will be found that a disease does not attack. For some reason the fungus cannot grow in it. By planting the seeds from a plant of this kind it is sometimes possible to get a type of plant that is not attacked by the disease. In some countries great progress has been made by breeding disease-resistant strains of plants.

Locusts. The most destructive insect in the Philippines is the locust, which sometimes flies from province to province and destroys all grass and palm vegetation where it alights. As a rule sweet potatoes, cassava, yams, tobacco, mungo, and cowpeas suffer little or no damage from locusts, and many fruit trees escape their attacks. A farmer, therefore, should have some of his crops of a kind that locusts do not destroy.

The life of the locust. At egg-laying time each female makes a hole in soft soil and deposits from 50 to 80 eggs in it. In about 14 days the eggs hatch into young locusts. For from 48 to 60 days these young locusts eat and grow but have no wings. After this time, however, they develop wings, fly about, mate, and lay more eggs, after which they die.

Destroying locusts. Locusts are destroyed in the following ways:

Egg destruction. In cultivated areas the plowing of egg-beds with plows that turn the soil over will destroy many

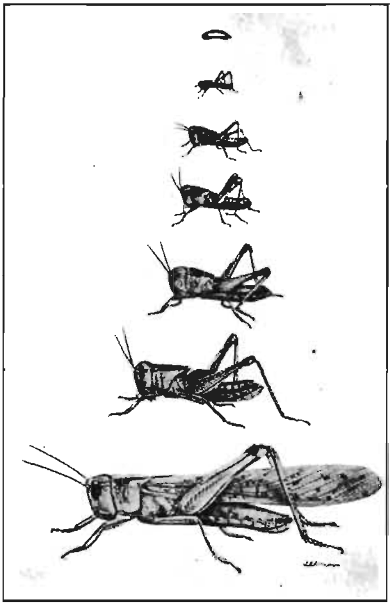


FIG. 164. The migratory locust, from egg to adult. It sheds its skin five times.

of the young. The plow stops up the holes that contain the eggs, and when the young locusts hatch they cannot escape to the surface. To roll soil thoroughly or tamp it after it is plowed will help to make this remedy more effective. In plowed soil ants destroy many of the locust eggs.

Pit method. This method consists of driving the young locusts into a pit or trench which is at the point of a V-shaped corral of sheet iron. Where iron cannot be secured, soil

dikes faced with sections of banana sheaths may be used. In constructing the corral, take care to prevent the young locusts

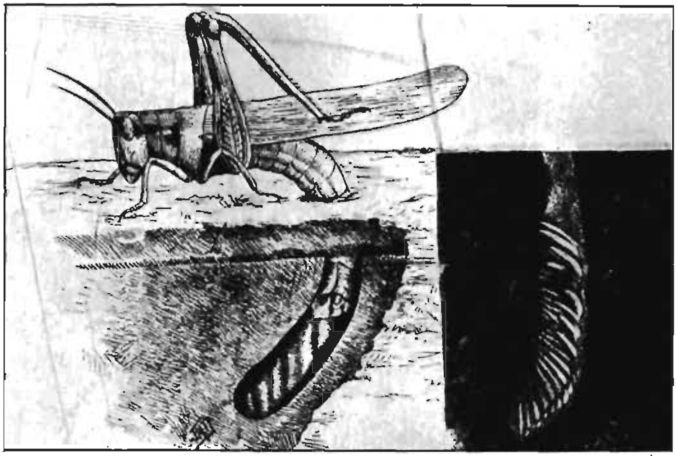


FIG. 165. Migratory locust depositing eggs in a hole in the ground.

from escaping between the joints or from crawling over the corral. The pit should be 1 meter in diameter and 1 meter deep. To prevent the young locusts from crawling out, face its upper edge with iron sheets or banana-leaf sheaths. The pit and the V-shaped corral should be made about 20 meters in advance of the swarm. By driving the young locusts slowly, a number of persons can within one hour drive a large swarm into a pit and there easily destroy it.

Drag-nets. This method consists of dragging a wide-mouthed, coarse-cloth bag or net rapidly through a swarm of young locusts. The side of the opening which comes in contact with the earth should be held straight by means of a straight stick, the upper part of the opening being held by a

bow-shaped strip of wood. The captured locusts can be killed by crushing them or by dipping them into hot water.

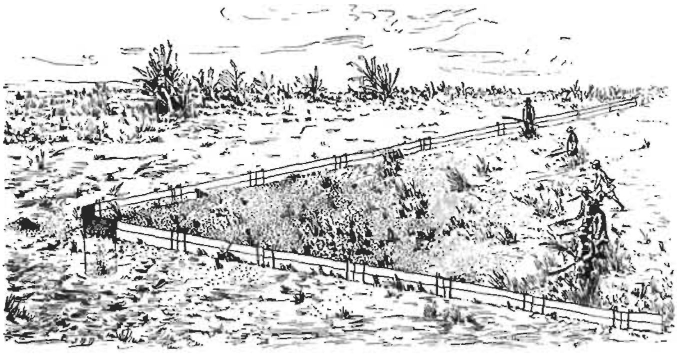


FIG. 166. Showing how a canal and pit should be constructed for locust destruction.

Burning. In mountain or cogon areas where locusts have deposited eggs, cut the grass over the place before the eggs hatch and, as soon as the locusts appear, burn the dry grass. The fire will destroy many of the young locusts.

Kerosene. Young locusts can be killed by spraying kerosene over them with a pump. Owing to the cost of kerosene, this method can be used only where locusts appear in great numbers and the swarms are compact. Kerosene emulsion may also be used.[1]

Reducing the areas where locusts breed. About 40 per cent of the land in the Philippines is now covered with coarse grass in which breed the millions of locusts that from time to time appear. If these grass-lands were all planted to ipil-

[1] The emulsion is made as follows: Dissolve 250 grams of soap in 4 liters of hot water. Add 8 liters of kerosene and stir thoroughly until a milky emulsion is formed. For use add 3 to 6 parts of water to 1 part of the emulsion.

ipil, lumbang, buri, kapok, or other productive trees, the breeding ground for locusts would be removed and the waste land made productive. These breeding places must be broken up before the Philippine farmers can ever be free from this pest.

Wild hogs, monkeys, deer, and dogs. The best way to prevent wild hogs and deer from destroying crops is to kill the animals, but where this is not possible a fence that will keep them out should be built. A woven wire fence is the best to keep out hogs.

Dogs are sometimes tied to cacao trees to bark and frighten monkeys away. This may be useful for a time, but the best plan is to kill the monkeys.

In some districts the dogs eat ripening corn. If these dogs are valuable, they should be fed by the owners and then they will not forage for their food. If the dogs are not valuable, they should be killed.

Deer may be prevented from eating the leaves of young cacao trees by constructing a bamboo framework around each tree.

Cattle and carabaos. Cattle and carabaos are often turned loose by the owners to pasture at large. They sometimes damage crops which are grown by some other farmer. The animals should be kept in an inclosure by the owners or herded by a caretaker. To protect crops a law is sometimes passed punishing the owners of cattle for allowing their animals to run loose.

Rats. Coconut trees are often injured by rats that climb the trees. Drive the rats from the trees and nail a band of tin or sheet iron around the trunk of each tree, 2 meters from the soil. Rats sometimes do considerable damage in fields of rice, corn, sweet potatoes, sugarcane, and coconuts.

Sometimes hundreds of them will visit a field during the dry season. These animals may be killed either by traps or by poisons. Small traps that catch one animal at a time are recommended. A piece of fresh coconut meat is excellent bait for a trap. Each time a rat is caught, dip the trap into boiling hot water to take the rat odor away.

In some cases the rats can be more easily killed by the use of poisons. A good rat poison can be made by mixing boiled rice, sweet potatoes, or grated coconut with white arsenic. The mixture should be stirred with a stick and should contain 25 per cent of the arsenic. The arsenic is a strong poison and it must not be allowed to get into cuts or scratches on the body. Be careful that farm animals and people do not get any of the poison.

Rats in a hole can be killed by placing in the hole a cloth soaked with carbon bisulfid and then closing the hole with moist soil. This substance takes fire readily, and all lighted lamps, cigarettes, and matches must be kept away from it. Certain kinds of snakes are decidedly beneficial because they destroy large numbers of rats. The only effective method of fighting rats, however, is to break up their breeding places. One pair of rats has been known to produce more than 80 young in a year, and it is impossible to trap or kill them as fast as they will multiply if they are given secure homes.

EXERCISES

Exercise 73. To study the relations of rainfall to agriculture. Make a rain gauge (for directions see Appendix of Book I) and keep a record of the rainfall by months. Write to the Weather Bureau at Manila for records showing the rainfall of your region in past years. Note the total amount and the distribution by months. What

crops may a farmer lose by too much or too little rainfall? Are there other crops which he can raise with less danger of loss?

Exercise 74. To study which losses on the farm are preventable. Make a list of the various losses that the farmers in the district suffer. Divide these into three classes, — preventable, partially preventable, and non-preventable. Which ones can an individual farmer escape by his own efforts? Which ones can all farmers of a community, working together, prevent? Which ones could be prevented by all the Filipino people working together?

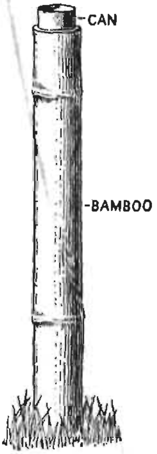


FIG. 167. A good rain gauge can be made from a bamboo stem and a tin can.

NOTE. The teacher should show the class that the greatest loss from these destructive agencies is that they prevent certain industries from developing. Thus poultry diseases cause little direct loss in the Philippines because little poultry is kept, but they cause very great loss by preventing the people from engaging in this branch of agriculture. In the same way, rinderpest can keep a natural cattle country from engaging in cattle growing, and coconut bud-rot can drive a district from copra production into much less profitable lines of agriculture. The class should be made to see the agricultural conditions that *might* exist if preventable losses were eliminated.

GLOSSARY

This glossary is intended chiefly to help in the pronunciation of the more difficult terms, which are not likely to be found in the pupils' small dictionaries. The numbers refer to pages on which will be found a definition or discussion of the different terms.

Acacia farnesiana (a-kā'shia far-nē-sĭ-ā'na), the botanical name for aroma; 196.
Agave (a-gä'vē), 182.
Aleurites moluccana (a-lūr-ī'tēz mŏ-lŭk-ā'na), lumbang; 192.
alluvial soil (a-loov'i-al), 144.
Ananas sativus (an-än'as sa-tī'vus), pineapple; 186.
Areca cathecu (ar'ĕ-ka ka-thē'kū), betel-nut; 198.
bichlorid (bī-klō'rĭd), 225.
Bordeaux mixture (bor'dō), 242
calcium (kal'sĭ-ŭm), 55.
capillarity (kap-ĭ-lăr'ĭ-tĭ), 86.
bisulfid (bī-sŭl'fĭd), 248.
Ceiba pentandra (sā'ē-bä pĕn-tăn'-dra), kapok; 180.
cinchona (sin-kō'na), 64.
coir (kīr), 122.
Corypha elata (kŏ'rĭ-fa ĕ-lā'ta), buri palm; 188.
Cynodon dactylon (sī'no-don dak'tĭ-lon), Bermuda grass; 20.
eri silkworm (ē'rĭ), 200.
fungus (fŭn'gus); plural, fungi (fŭn'-jī); adjective, fungous (fŭn'gus); 238, 240.
gapes (gāps), 224.
Gliricidia sepium (glĭ-rĭ-sĭd'i-a sē'-pi-ŭm), cacauate; 196.
Gossypium (gŏ-sĭp'i-ŭm), cotton; 177.
henequen (hĕ'nĕ-kĕn), 182.
hydrogen (hī'drō-jĕn), 55.
magnesium (mag-nē'zhi-ŭm), 55.
microörganism (mī'krō-or'gan-izm), 11.
migratory (mī'gra-tō-rĭ), 244.
Nicotiana tabacum (nĭ-ko-ti-ā'na ta-bă'kum), tobacco; 166.
nicotine (nĭ'kō-tĭn), 166.
nitrate (nī'trāt), 56.
nitrogen (nī'trō-jĕn), 55.
Oryctes rhinoceros (ŏ-rĭk'tēz rī-nŏs'-er-ŏs), rhinoceros beetle; 126.
Oryza sativa (ŏ-rī'za sa-tī'va), rice; 96.
oxygen (ŏx'ĭ-jĕn), 55.
Pandanus sabotan (pan-dā'nŭs sa-bō'tan), sabutan; 189.
phosphorus (fos'for-ŭs); adjective, phosphoric (fos-for'ik); 55, 56.
Piper betle (pī'per bē'tl), betel-leaf; 197.
potassium (pō-tăs'i-um), 55.
permanganate (per-man'ga-nāt), 223.
pyralid (pī'ra-lid), 160.
Rhynocophorus ferrugineus (rī-nō-cŏf'or-ŭs fĕ-rŭ-jĭn'ē-ŭs), Asiatic palm-weevil; 127.
Ricinus communis (rĭ-sī'nus co-mū'-nis), castor plant; 190.
roup (rōōp), 222.
Saccharum officinarum (sak'a-rum o-fĭ-sĭ-nā'rum), sugarcane; 140.
tuberculosis (tū-ber'kū-lō'sis), 225.
Zea mays (zē'a mä'is), corn; 150.

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